SAR Altimetry Processing On Demand Service For CryoSat-2 and Sentinel-3 At ESA G-POD

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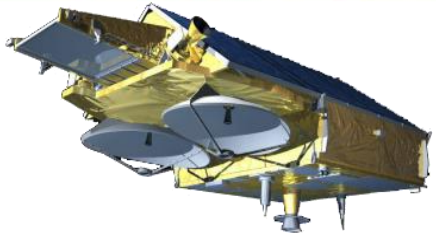
(1) ESA-ESRIN, (2) CLS, (3) Progressive Systems/ESRIN-RSS, (4) SERCO/ESRIN, (5) DEIMOS/ESRIN

The G-POD Sentinel-3 & CryoSat-2 SAR/SARin Processing service

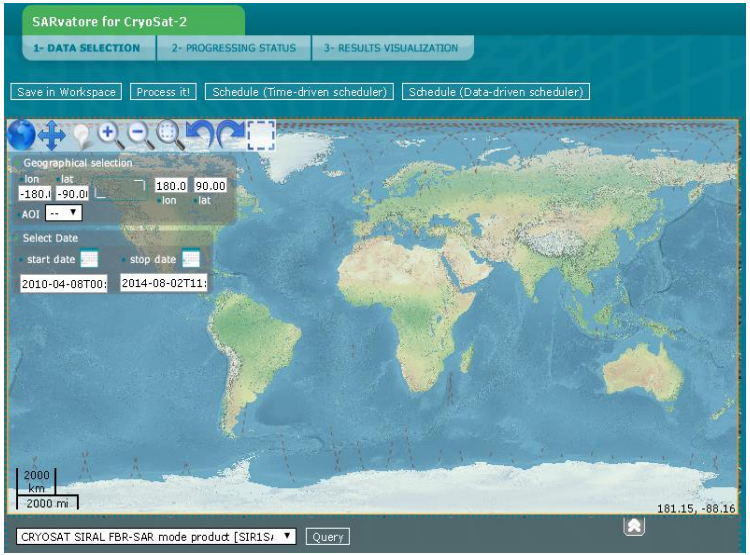
The G-POD Sentinel-3 & CryoSat SAR/SARin Processing service is a web platform that provides the capability to process on line and on demand Sentinel-3 SAR and CryoSat SAR and SARin data, from L1a (FBR) data products until SAR/SARin Level-2 geophysical data products.



The service, coined **SARvatore** (**SAR V**ersatile **A**ltimetric **TO**olkit for **R**esearch & **E**xploitation), can process data over any surface.

The service is available at:

https://gpod.eo.esa.int/services/CRYOSAT_SAR
https://gpod.eo.esa.int/services/CRYOSAT_SARIN
https://gpod.eo.esa.int/services/SENTINEL3_SAR



The G-POD Sentinel-3 & CryoSat-2 SAR/SARin Processing service

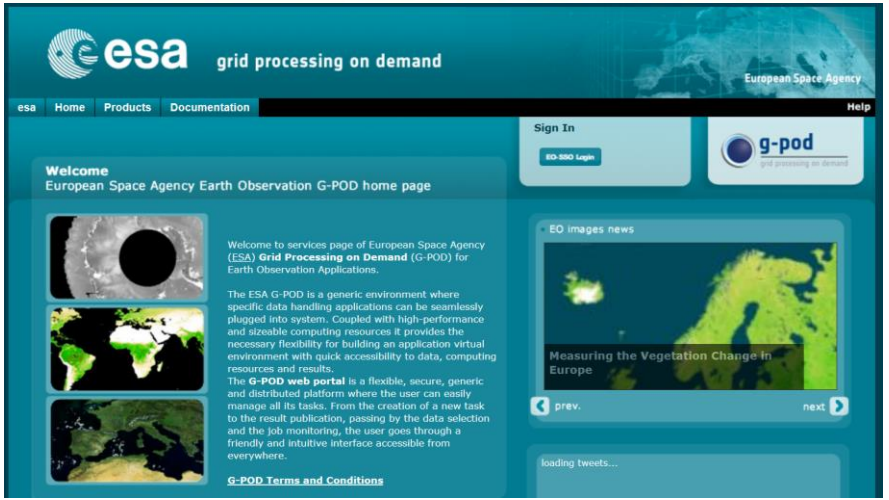
The service is **open, free of charge and accessible on line from everywhere**.

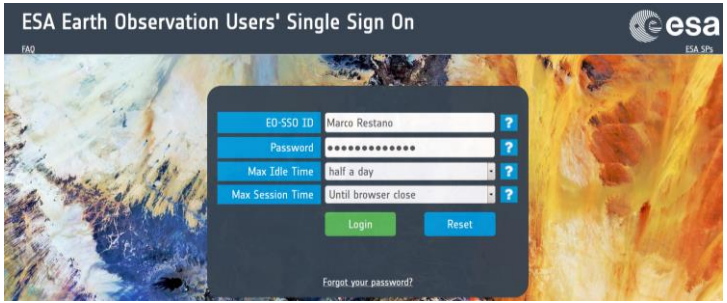
In order to be granted access to the service, you need to have EO-SSO (Earth Observation Single Sign-On) credentials.

For registration, go to **https://earth.esa.int/web/guest/general-registration**) and afterwards, you need to submit an e-mail to G-POD team (write to **eo-gpod@esa.int),** requesting the activation of the CryoSat-2/Sentinel-3 service for your EO-SSO user account.

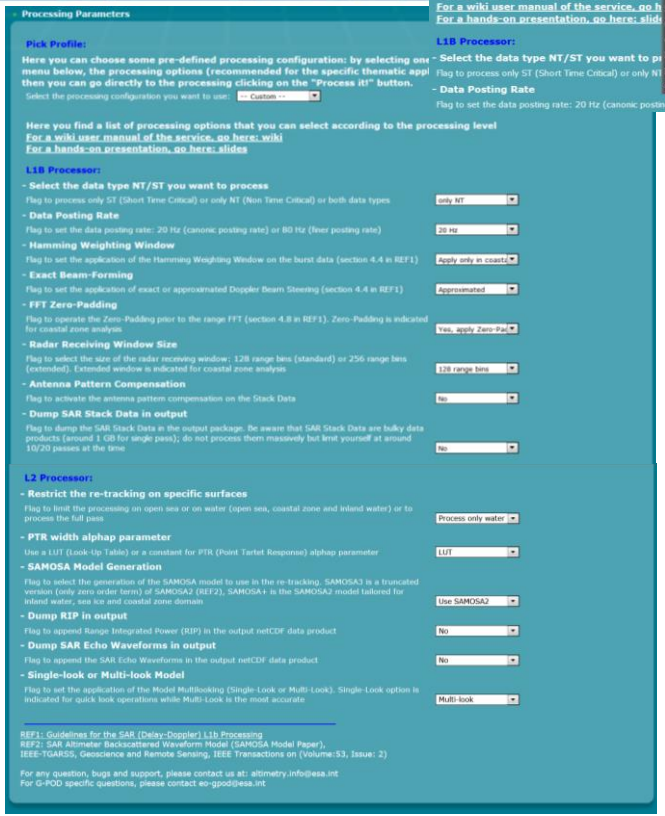
The service was made available on 10 June 2014 accumulating now more than **six years** of intense exploitation and usage with many studies now published in peer-reviews journals (full bibliography available).

The GPOD/SARvatore service has 202 Users supported with: 3150033 CPU hours (that's 360 years), 71938 processing tasks completed (since the beginning) and 929.60 TB processed (since the beginning).





The G-POD Sentinel-3 & CryoSat-2 SAR/SARin Processing service



The processor prototype is versatile, allowing users to customize and to adapt the processing according to their specific requirements by setting a list of configurable options.

Pre-defined processing configurations **(Official CryoSat-2, Official Sentinel-3, Open Ocean, Coastal Zone, Inland Water (20Hz & 80Hz), Ice and Sea-Ice**) are available.

The configurable options are divided according to the processing level they refer to (L1b and L2).

The system allows the user to follow the task status in real time, append to the output product the **SAR/SARIN Echo Waveforms** & **Range Integrated Power Waveforms**, build **SAR/SARIN Stack Data** and **retrack SAR L1b waveforms** with both SAMOSA retrackers optimised for the various applications (**SAMOSA2, SAMOSA3 and SAMOSA+**) and the empirical **ALES+ SAR** retracker.

A **new** retracker (**SAMOSA++**) has been developed and will be made available in the future.

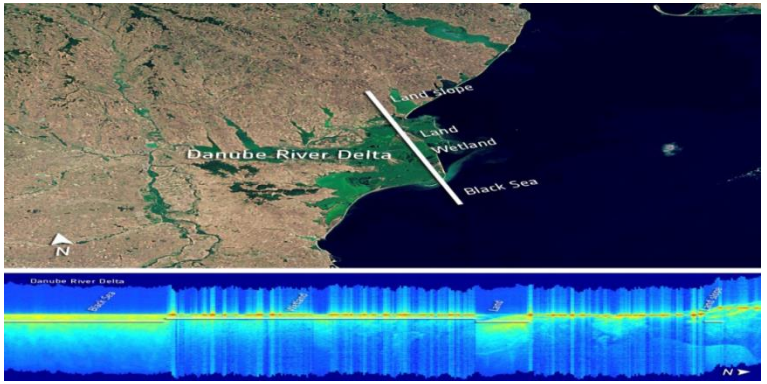
The G-POD Sentinel-3 & CryoSat-2 SAR/SARin Processing service

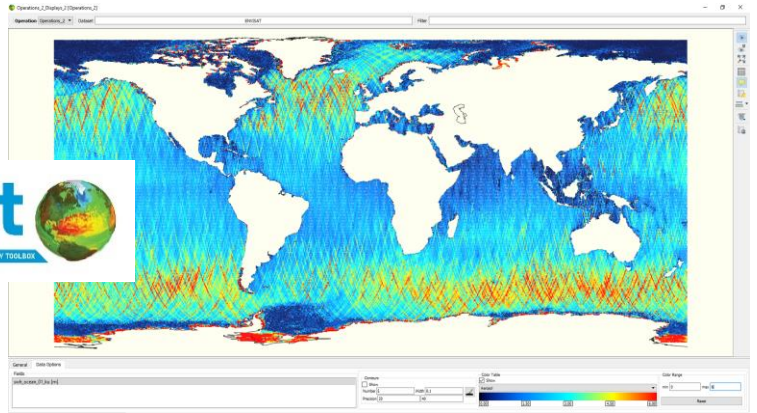
- At the end of the run, the output can be downloaded from the service's portal by way of a simple click or uploaded directly to the user's personal ftp as a tar.gz package. The output package **consists** of

  - A pass Ground-Track in KML format.
  - A Radar Echogram Picture in PNG format.
  - An L2 data product in NetCDF format.

- The output NetCDF file can be ingested in **BRAT (Broadview Radar Altimetry Toolbox)** to browse, visualize, edit and export the output content.

- The toolbox and tutorial are available at **earth.esa.int/brat**

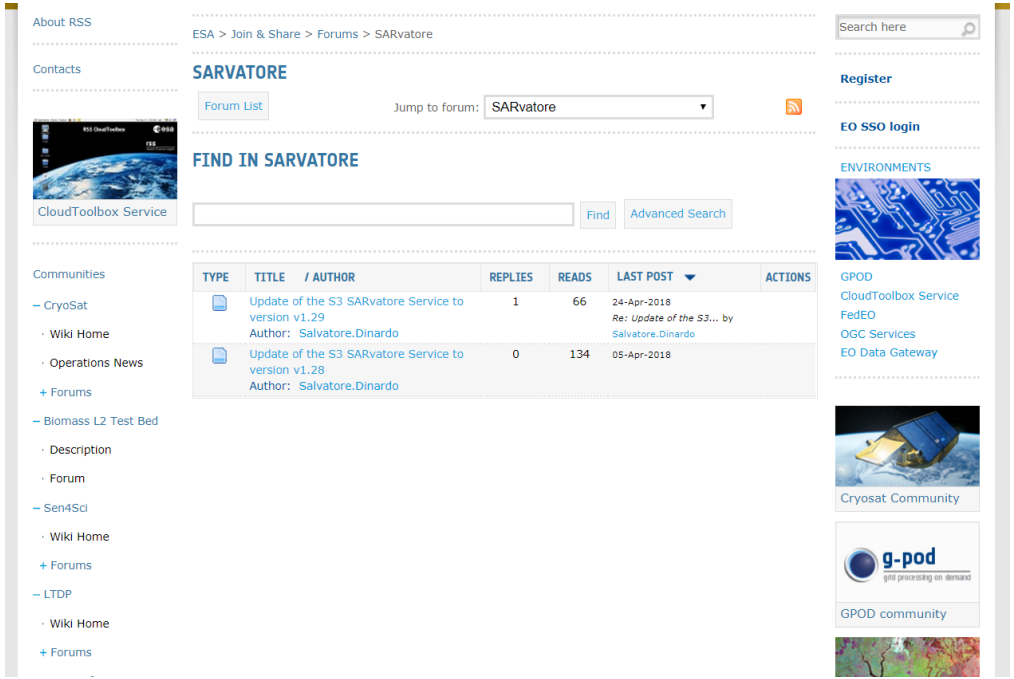




Joins & Share SARvatore Forum

- **J/S Forum**: users can get here the last updates & releases and report issues, ask questions, share & discuss results:

https://wiki.services.eoportal.org/tiki-view_forum.php?forumId=105



Data Repository

Data Repository: The **SARvatore Data Repository** is now online.

Datasets processed for the users are available to the Altimetry Community at:

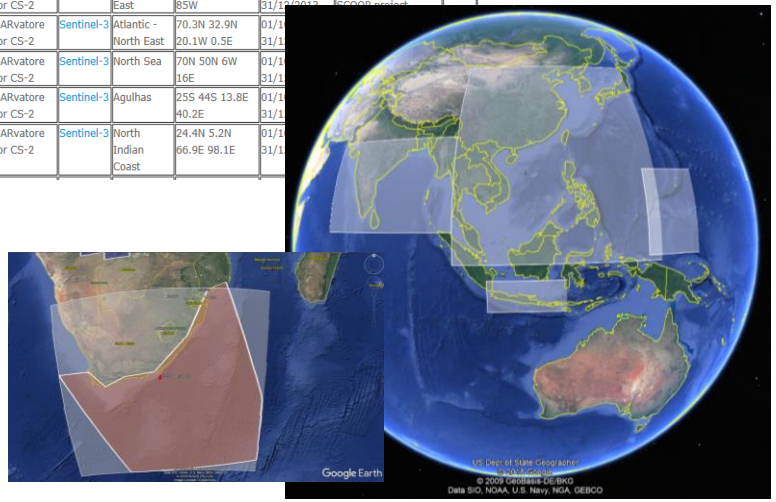
https://wiki.services.eoportal.org/tiki-index.php?page=SARvatore+Data+Repository&highlight=repository

- A .kmz file can be downloaded to visualize in Google Earth the processed regions and compare, for example, to the CS-2 geographical mode mask.

SARVATORE DATA REPOSITORY

This page is a repository of Data processed in G-POD with SARvatore service. Data are available for download.

USER	SERVICE	PROFILE	REGION	COORDINATES	START-STOP TIME	PURPOSE OF THE PROCESSING	DATA
S. Dinardo	SARvatore for S3	Custom	Atlantic - North East	60N 35N 12W 16E	15/06/2016 09/05/2018		0001
SCOOP Team	SARvatore for CS-2	Sentinel-3	Pacific - West	17.1N 0N 137E 150E	01/10/2012 31/12/2013	Support to the SCOOP project	0002
SCOOP Team	SARvatore for CS-2	Sentinel-3	Pacific - Central	25.2N 15N 180W 167W	01/10/2012 31/12/2013	Support to the SCOOP project	0003
SCOOP Team	SARvatore for CS-2	Sentinel-3	Pacific - East	4.6S 25S 140W 85W	01/10/2012 31/12/2013	Support to the SCOOP project	0004
SCOOP Team	SARvatore for CS-2	Sentinel-3	Atlantic - North East	70.3N 32.9N 20.1W 0.5E	01/1 31/1		
SCOOP Team	SARvatore for CS-2	Sentinel-3	North Sea	70N 50N 6W 16E	01/1 31/1		
SCOOP Team	SARvatore for CS-2	Sentinel-3	Agulhas	25S 44S 13.8E 40.2E	01/1 31/1		
SCOOP Team	SARvatore for CS-2	Sentinel-3	North Indian Coast	24.4N 5.2N 66.9E 98.1E	01/1 31/1		



Recent Updates

New Cluster Element: CREODIAS.

The new cluster exploits the cloud computing and cloud storage based on the CREODIAS platform (https://creodias.eu/).

In the CREODIAS cluster set-up, all the products get processed in local avoiding time-consuming data transfers.

Recent Updates (2)

CS2 SARvatore & SARinvatore Services

Services updated to process CryoSat-2 Baseline D data which have recently entered in operation.

CS2/S3 SARvatore & CS2 SARinvatore Services now include:

- Possibility to dump SAR stack in Power and Phase for both the two channels (option from Graphic Interface, available only in the SARinvatore for CS-2 Service).

- Add epoch field and Epoch Reference Gate field in the products.

- Addition of the Leap Second in the products.

Recent Updates (3)

CS2/S3 SARvatore & CS2 SARinvatore Services now include:

- Support to CLS15 Mean Sea Surface in the product
- Support to J2 Sea State Bias Model in the product
- Support to NSIDC Sea Ice Concentration in the product
- Support to NSIDC Sea Ice Age in the product
- Support to FES2014b Tide Model in the product
- Support to TPXO9 Tide Model in the product
- Support to DTU18 Mean Sea Surface in the product
- Support to CLS13 Mean Dynamic Topography in the product
- Support to GPCC Precipitation Rate in the product
- Support to distance to land based on GSHHG database

Recent Updates (4)

CS2/S3 SARvatore & CS2 SARinvatore Services now include:

- New fields in the products GEO_Corr_SeaIce and GEO_Corr_Land.

- When Waveform is Hamming-weighted, a dedicated LUT is used now.

- Addition of First Guess Epoch and Epoch Bounds in the product.

- Fix of a bug of distance to land field for latitude around +88.

- Support to CryoSat-2 Baseline D FBR/L1b Products.

- A GUI with Relative Orbit Number Filter, Ascending/Descending Filter and Summary Report & a function to compute geodetic distance (dmt).

Recent Updates (5)

CS2/S3 SARvatore Services now include:

The possibility to post-process the data with the **ALES+ SAR retracker**.

ALES+ SAR is a subwaveform retracker for open ocean and coastal zone SAR altimetry data.

ALES+ SAR L2 NetCDF products will be placed into a dedicated output folder.

Further information on this algorithm can be found in http://doi.org/10.5270/esa.BalticSEAL.ATBDV1.1

Please check the two other OSTST2020 presentations:

- The ALES+ SAR Service for Cryosat-2 and Sentinel-3 at ESA GPOD by Passaro et al.
- Investigating SAR Altimetry over the Great Salt Lake – Comparing SAMOSA+/++ and ALES+ SAR by Wenzl et al.

Implementation of Processors Developed by the Users

- The ESA-ESRIN R&D Altimetry Team and the ESA GPOD Team support users who want to include their processors in GPOD/SARvatore.

- If interested, please send an email to:

eo-gpod@esa.int **altimetry.info@esa.int**

Support SARvatore!

To support the future availability of SARvatore services on the GPOD platform, users are kindly invited to provide feedback on the service to **eo-gpod@esa.int**

Papers published using SARvatore data

2015

Dinardo S., B. Lucas and J. Benveniste, "**Sentinel-3** STM SAR ocean retracking algorithm and SAMOSA model," 2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Milan, 2015, pp. 5320-5323. doi: 10.1109/IGARSS.2015.7327036

Fenoglio-Marc L., S. Dinardo, R. Scharroo, A. Roland, M. Dutour Sikiric, B. Lucas, M. Becker, J. Benveniste, R. Weiss, The German Bight: A validation of **CryoSat-2** altimeter data in SAR mode, Advances in Space Research, Volume 55, Issue 11, 2015, Pages 2641-2656, ISSN 0273-1177, https://doi.org/10.1016/j.asr.2015.02.014.

Scagliola M., S. Dinardo and M. Fornari, "An extended analysis of along-track antenna pattern compensation for **SAR altimetry**," 2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Milan, 2015, pp. 1238-1241. doi: 10.1109/IGARSS.2015.7325997

Papers published using SARvatore data

2016

Gómez-Enri, J.; Scozzari, A.; Soldovieri, F.; Coca, J.; Vignudelli, S. Detection and Characterization of Ship Targets Using **CryoSat-2** Altimeter Waveforms. Remote Sens. 2016, 8, 193. https://doi.org/10.3390/rs8030193

Passaro Marcello, Salvatore Dinardo, Graham D. Quartly, Helen M. Snaith, Jérôme Benveniste, Paolo Cipollini, Bruno Lucas, Cross-calibrating ALES Envisat and **CryoSat-2** Delay–Doppler: A coastal altimetry study in the Indonesian Seas, Advances in Space Research, Volume 58, Issue 3, 2016, Pages 289-303, ISSN 0273-1177,https://doi.org/10.1016/j.asr.2016.04.011.

Papers published using SARvatore data

2017

Boergens, E., Nielsen, K., Andersen, O., Dettmering, D., Seitz, F. (2017): River Levels Derived with **CryoSat-2** SAR Data Classification—A Case Study in the Mekong River Basin. - Remote Sensing, 9, 12. https://doi.org/10.3390/rs9121238

Cipollini, Paolo; Calafat, Francisco M.; Jevrejeva, Svetlana; Melet, Angelique; Prandi, Pierre (2017), Monitoring sea level in the coastal zone with coastal altimetry and tide gauges. Surveys in Geophysics, 38 (1). 33-57.https://doi.org/10.1007/s10712-016-9392-0

Gomez-Enri, Jesus & Vignudelli, S & Cipollini, P & Coca, Josep & González, Carlos. (2017). Validation of **CryoSat-2** SIRAL sea level data in the eastern continental shelf of the Gulf of Cadiz (Spain). Advances in Space Research. https://doi.org/10.1016/j.asr.2017.10.042.

Papers published using SARvatore data

2017

Idžanović, M., Ophaug, V., and Andersen, O. B. (2017), The coastal mean dynamic topography in Norway observed by **CryoSat-2** and GOCE, Geophys. Res. Lett., 44, 5609–5617, doi:10.1002/2017GL073777.

Passaro M., Müller F., Dettmering D.: Lead Detection using **Cryosat-2** Delay-Doppler Processing and **Sentinel-1** SAR images. Advances in Space Research, 10.1016/j.asr.2017.07.011, 2017

Papers published using SARvatore data

2018

Abdalla S., Salvatore Dinardo, Jérôme Benveniste, Peter A.E.M. Janssen, Assessment of **CryoSat-2** SAR mode wind and wave data, Advances in Space Research, Volume 62, Issue 6, 2018, Pages 1421-1433, ISSN 0273-1177, https://doi.org/10.1016/j.asr.2018.01.044.

Buchhaupt C., L. Fenoglio-Marc, S. Dinardo, R. Scharroo, M. Becker, A fast convolution based waveform model for conventional and unfocused **SAR altimetry**, Advances in Space Research, Volume 62, Issue 6, 2018, Pages 1445-1463, ISSN 0273-1177, https://doi.org/10.1016/j.asr.2017.11.039.

Bonnefond, P.; Laurain, O.; Exertier, P.; Boy, F.; Guinle, T.; Picot, N.; Labroue, S.; Raynal, M.; Donlon, C.; Féménias, P.; Parrinello, T.; Dinardo, S. Calibrating the SAR SSH of **Sentinel-3A and CryoSat-2** over the Corsica Facilities. Remote Sens. 2018, 10, 92. https://doi.org/10.3390/rs10010092

Papers published using SARvatore data

2018

Dettmering D., Wynne A., Müller F.L., Passaro M., Seitz F.: Lead Detection in Polar Oceans—A Comparison of Different Classification Methods for **CryoSat-2** SAR Data. Remote Sensing, 10(8), 1190, https://doi.org/10.3390/rs10081190, 2018

Dinardo Salvatore, Luciana Fenoglio-Marc, Christopher Buchhaupt, Matthias Becker, Remko Scharroo, M. Joana Fernandes, Jérôme Benveniste, Coastal **SAR and PLRM altimetry** in German Bight and West Baltic Sea, Advances in Space Research, Volume 62, Issue 6, 2018, Pages 1371-1404, ISSN 0273-1177, https://doi.org/10.1016/j.asr.2017.12.018.

Tournadre, Jean & Bouhier, Nicolas & Boy, Francois & Dinardo, Salvatore. (2018). Detection of iceberg using Delay Doppler and interferometric **CryoSat-2** altimeter data. Remote Sensing of Environment. 212. https://doi.org/10.1016/j.rse.2018.04.037. Advances in Space Research,

Papers published using SARvatore data

2019

Bonnefond, P., Exertier, P., Laurain, O., Guinle, T., Féménias, P. (2019) Corsica: A 20-Yr Multi-Mission Absolute Altimeter Calibration Site, Advances in Space Research, Special Issue « 25 Years of Progress in Radar Altimetry », doi : 10.1016/j.asr.2019.09.049.

Fenoglio L., S. Dinardo, B. Uebbing, C. Buchhaupt, J. Kusche, M. Becker (2019). Calibrating CryoSat-2 ad Sentinel-3A sea surface heights along the German coast, In: International Association of Geodesy Symposia, Springer, Berlin, Heidelberg, https://doi.org/10.1007/1345_2019_73

Idžanović, M.; Gerlach, C.; Breili, K.; Andersen, O.B. An Attempt to Observe Vertical Land Motion along the Norwegian Coast by **CryoSat-2** and Tide Gauges. Remote Sens. 2019, 11, 744. https://doi.org/10.3390/rs11070744

Papers published using SARvatore data

2019

Jiang Liguang, Ole Baltazar Andersen, Karina Nielsen, Guoqing Zhang, Peter Bauer-Gottwein, Influence of local geoid variation on water surface elevation estimates derived from **multi-mission altimetry** for Lake Namco, Remote Sensing of Environment, Volume 221,2019, Pages 65-79, ISSN 0034-4257, https://doi.org/10.1016/j.rse.2018.11.004.

Lawrence Isobel R., Thomas W.K. Armitage, Michel C. Tsamados, Julienne C. Stroeve, Salvatore Dinardo, Andy L. Ridout, Alan Muir, Rachel L. Tilling, Andrew Shepherd, Extending the Arctic sea ice freeboard and sea level record with the **Sentinel-3** radar altimeters, Advances in Space Research, 2019, https://doi.org/10.1016/j.asr.2019.10.011

Muzaffar R., R. Z. Khalil, S. ul Haque, A. Zaidi and S. Zafer, "Volumetric Vairations of Inland Water Body: A Case STDY of Manchar Lake," IGARSS 2019 - 2019 IEEE International Geoscience and Remote Sensing Symposium, Yokohama, Japan, 2019, pp. 6911-6914. doi: 10.1109/IGARSS.2019.8900476

Papers published using SARvatore data

2019

Ophaug Vegard, Kristian Breili, Ole Baltazar Andersen, A coastal mean sea surface with associated errors in Norway based on **new-generation altimetry**, Advances in Space Research, 2019, https://doi.org/10.1016/j.asr.2019.08.010.

Quartly, G. et al. , M. Retrieving Sea Level and Freeboard in the Arctic: A Review of Current Radar Altimetry Methodologies and Future Perspectives. Remote Sens. 2019, 11, 881

Scagliola M., Lisa Recchia, Luca Maestri, Davide Giudici, Evaluating the impact of range walk compensation in **delay/Doppler** processing over open ocean, Advances in Space Research, 2019, https://doi.org/10.1016/j.asr.2019.11.032.

Schroeder S., et al. (2019). Niger discharge from radar altimetry: bridging gaps between gauge and altimetry time series Hydrol. Earth Syst. Sci., 23, 4113–4128, 2019 https://doi.org/10.5194/hess-23-4113-2019

Papers published using SARvatore data

2020

Abulaitijiang a. et al., "Coastal marine gravity modelling from satellite altimetry -- case study in the Mediterranean", accepted in Journal of Geodetic Science (2020)

Dinardo S. (2020): Techniques and Applications for Satellite **SAR Altimetry** over water, land and ice. Heft 56, ISBN 978-3-935631-45-7. Doctoral dissertation.Technische Universität Darmstadt

Liguang Jiang, Karina Nielsen, Salvatore Dinardo, Ole B. Andersen, Peter Bauer-Gottwein, Evaluation of **Sentinel-3** SRAL SAR altimetry over Chinese rivers, Remote Sensing of Environment, Volume 237, 2020, 111546, ISSN 0034-4257, https://doi.org/10.1016/j.rse.2019.111546.

Contacts & References

- For any question, bugs and support, please contact us at:
  altimetry.info@esa.int

- For G-POD platform specific questions and get access to the service, please contact:
  eo-gpod@esa.int

- Service Manuals available at:

http://wiki.services.eoportal.org/tiki-index.php?page=GPOD+CryoSat-2+SARvatore+Software+Prototype+User+Manual

http://wiki.services.eoportal.org/tiki-index.php?page=GPOD+SENTINEL-3+SARvatore+Software+Prototype+User+Manual

- Services available at:
  https://gpod.eo.esa.int/services/CRYOSAT_SAR/
  https://gpod.eo.esa.int/services/CRYOSAT_SARIN/
  https://gpod.eo.esa.int/services/SENTINEL3_SAR/