HYDROCOASTAL

SAR/SARin Radar Altimetry for Coastal Zone and Inland Water Level

Requirements Baseline
Deliverable D1.2

Sentinel-3 and Cryosat SAR/SARin Radar Altimetry for Coastal Zone and Inland Water
ESA Contract 4000129872/20/I-DT

Project reference: HYDROCOASTAL_ESA_RB_D1.2
Issue: 1.1

10/09/20

This page has been intentionally left blank

Change Record

Date	Issue	Section	Page	Comment
25/06/20	1.0			First version
10/09/20	1.1	Various		Minor revisions following ESA Review

Control Document

Process	Name	Date
Written by:	H. Ranndal, K. Nielsen, O. B. Andersen	25/06/20
Checked by	D. Cotton	09/10/20
Approved by:	D. Cotton	09/10/20

Subject	Radar Altimetry for Coastal Zone and Inland Water Level	**Project**	HYDROCOASTAL
Author	**Organisation**	**Internal references**	
		HYDROCOASTAL_ESA_RB_D1.2	

	Signature	Date
For HYDROCOASTAL team		09/10/20
For ESA		

Table of contents

1. Introduction

1.1. The HYDROCOASTAL Project

The HYDROCOASTAL project is funded under the ESA EO Science for Society Programme, and aims to maximise the exploitation of SAR and SARin altimeter measurements in the coastal zone and inland waters, by evaluating and implementing new approaches to process SAR and SARin data from CryoSat-2, and SAR altimeter data from Sentinel-3A and Sentinel-3B.

One of the key objectives is to link together and better understand the interactions processes between river discharge and coastal sea level. Key outputs are global coastal zone and river discharge data sets, and assessments of these products in terms of their scientific impact.

1.2. Scope of this Report

This is the Requirements Baseline for HYDROCOASTAL and represents D1.2 of the project. The document will review the status of current processing algorithms, whether they are mature and ready for implementation before selecting the algorithms to be applied in generating the Test Data Set. The document also lists the content and coverage (geographically and in time), the source data for generating this data set and the auxiliary data needed to do so. The document also specifies the data needed to carry out the different validation activities. The geographical coverage of the Test Data Set will take into account the requirement to cover a range of topographies and sea state conditions.

1.3. Applicable Documents

AD-01: Sentinel-3 and CryoSat SAR/SARin Radar Altimetry for COASTAL ZONE and INLAND WATER - Statement of Work, V1.0 10/01/2019 Ref: EOP-SD-SOW-2018-089

1.4. Reference Documents

RD-01 HYDROCOASTAL Technical Proposal. V1.1 28/11/2019, SatOC and HYDROCOASTAL team.

RD-02 HYDROCOASTAL Implementation Proposal. V1.1 28/11/2019, SatOC and HYDROCOASTAL.

RD-03 HYDROCOASTAL Management Proposal. V1.3 26/11/2019, SatOC and HYDROCOASTAL team

RD-04 HYDROCOASTAL Financial Proposal. V1.2 28/11/2019, SatOC and HYDROCOASTAL team

RD-05 HYDROCOASTAL Contractual Proposal. V 1.2 26/11/2019, SatOC and HYDROCOASTAL team

1.5.Document Organisation

After this introductory section, a review of the different methods used within the HYDROCOASTAL project is found in Section 2, followed by the specification of the input satellite data in Section 3. Section 4 holds the specification of auxiliary data such as tidal models and masks, and Section 5 lists all the test areas that will be used for phase 1 and phase 2 validation. All of this is concluded with a brief discussion in Section 6.

2. Review of Methods

This section describes the various methods used within the HydroCoastal project. For every method, the required input parameters and auxiliary data are listed, and the maturity and limitations of the methods are

2.1.Delay-Doppler processing (isardSAT)

Table 2.1: Information about the Delay-Doppler processing

Required input parameters	L1A (S3) FBR (CS2)
Required auxiliary data	None
Maturity	High (successfully applied in similar projects)
Limitations	Along-track resolution of 300m
Reference	Makhoul, E., Roca, M., Ray, C., Escolà, R., & Garcia-Mondéjar, A. (2018). Evaluation of the precision of different Delay-Doppler Processor (DDP) algorithms using CryoSat-2 data over open ocean. *Advances in Space Research*, *62*(6), 1464-1478.

2.2.Shape 2- Step Analytical (isardSAT)

Table 2.2: Shape 2-step analytical retracker

Required input parameters	L1B (S3/CS2)
Required auxiliary data	None
Maturity	High (Shape, S3MPC)
Limitations	Clean leading edge required

Reference	Gao, Q.; Makhoul, E.; Escorihuela, M.J.; Zribi, M.; Quintana Seguí, P.; García, P.; Roca, M. Analysis of Retrackers' Performances and Water Level Retrieval over the Ebro River Basin Using Sentinel-3. Remote Sen. 2019, 11, 718.

2.3.Specialised SARIn (Aresys)

Table 2.3: Specialised SARIn retracker

Required input parameters	CryoSat SARin Level1b
Required auxiliary data	DEM (geoid or mss)
Maturity	Prototype
Limitations	Performance still to be assessed. Until now, it has been applied on a limited test data set of CryoSat SARin acquisitions over ocean.
Reference	L. Recchia, M. Scagliola, D. Giudici and M. Kuschnerus, "An Accurate Semianalytical Waveform Model for Mispointed SAR Interferometric Altimeters," in *IEEE Geoscience and Remote Sensing Letters*, vol. 14, no. 9, pp. 1537-1541, Sept. 2017, doi: 10.1109/LGRS.2017.2720847.

2.4.MWaPP (DTU Space)

Table 2.4: Information about the Multiple Waveform Persistent Peak (MWaPP) retracker.

Required input parameters	CryoSat-L1b (as well as some corrections from L2) Sentinel-3 enhanced product
Required auxiliary data	Water mask (Currently the Global Surface Water Explorer occurrence data described in Section
Maturity	Has been used for several studies by multiple authors in a version using no auxiliary data.
Limitations	Empirical approach that does not provide information about SWH or wind speeds.
Reference	Villadsen, H., Deng, X., Andersen, O.B., Stenseng, L., Nielsen, K. & Knudsen, P. (2016):

	Improved inland water levels from SAR altimetry using novel empirical and physical retrackers, *Journal of Hydrology, 537*, https://doi.org/10.1016/j.jhydrol.2016.03.051

2.5.ICC Empirical Retracker (ATK)

Table 2.5: Information about the ICC empirical retracker.

Required input parameters	L1B-S (S3 and CS2) and user set parameters (Maximum Number of Major Peaks, Noise-To-Peak Ratio)
Required auxiliary data	None
Maturity	Prototype
Limitations	None
Reference	Not published yet, paper being prepared.

2.6.Statistical Retracker STAR type (U Bonn)

Table 2.6: Information about the statistical STAR type retracker.

Required input parameters	L1B-S (S3 and CS2) and parameters results of transformation from L1A to L1B and parameters usually in L2 (e.g. Doppler frequencies, slant-ranges, etc. see Annexe with list sent on 25.03.2020 and dated 18.03.2020). https://uni-bonn.sciebo.de/s/tqYtKZvbNfP3ght
Required auxiliary data	Distance to coast, mean sea surface
Maturity	Prototype
Limitations	SINCS model used for SAR in open sea, STAR retracker used for LRM and RDSAR in coastal and open ocean. Performance of merge has to be assessed.
Reference	Buchhaupt et al. (2018): A fast convolutional based waveform model for conventional and unfocused SAR altimetry. *ASR*, 62(6), 1445-1463, https://doi.org/10.1016/j.asr.2017.11.039. Roscher et al. (2017): STAR: Spatio-temporal altimeter waveform retracking using sparse representation and conditional random fields.*RSE*, 201, 148-164, https://doi.org/10.1016/j.rse.2017.07.024.

2.7.ALES+ for SAR (TUM)

Table 2.7: Information about the ALES+ retracker.

Required input parameters	L2 enhanced product as in the original EUMETSAT files
Required auxiliary data	None
Maturity	The retracker is fully operative in the context of other projects and has already gone through regional validation in both coastal, open ocean and sea-ice-covered ocean. Written in python, exportable in git and conda environment. A Sea State Bias model specifically for the retracker has been already computed and the Sea State Bias correction is provided as output.
Limitations	No limitations for the computation of sea level. Significant Wave Height is not included in the outputs.
Reference	ESA Baltic+ SEAL project ATBD, soon to be available from http://balticseal.eu/

2.8.Specialised COastal OPerator for SAR - SCOOP-SAR (NOC)

Table 2.8: Baseline requirements for SCOOP-SAR algorithm

Required input parameters	L1B-S (Stack, Doppler Angles,..) L2 enhanced (inc. waveform)
Required auxiliary data	None
Maturity	Prototype
Limitations	Only tested on a small number of C2 SAR mode tracks so far.
Reference	SCOOP Technical Note (in prep)

2.9.L3 River Level (AHL, DTU Space)

Table 2.9.1: Information about the L3 river level processing proposed by AHL.

Required input parameters	L2 product files with high rate variables: time, longitude, latitude, altitude, retracked range outputs, geophysical corrections (DTW/WTC, iono, solid Earth & pole tides, recent geoid) and

	specific add-on variables: • for SARINM data: longitude & latitude of the platform AND of the retracked echo, • for CryoSat-2 data: measurement mode flag telling if data are in LRM, SARM or SARINM. • for Sentinel-3, this flag shall always take the SARM value.
Required auxiliary data	Water Mask, organised in geographical tile files of reasonable size, e.g., 1°×1°.
Maturity	Some pieces of the algorithm inherits from ESA's SHAPE project and other past projects while others are new. Maturity is different for the three cases that will be handled by the algorithm: 1. Repeat orbit / SARM: Good [=SHAPE/S3A] 2. Non-repeat orbit / SARM: New 3. Non-repeat orbit / SARINM: New
Limitations	Since the algorithm is designed for **global scale processing**, by design, it will be able to process CryoSat-2 **non-repeat orbit data** with limited capability in terms of outliers rejection. Such orbit data needs cancelation of the spatial variability in the water level measurements in order to obtain time series. This requires river profile data. However, in the frame of this project, it is not possible to estimate river profiles at global scale. Other information such as L2 quality flags will be investigated.
Reference	SHAPE's project, cf. https://projects.along-track.com/shape/ N. Bercher PhD Thesis (2008)

Table 2.9.2: Information about the L3 river level processing proposed by DTU Space.

Required input parameters	Latitude and longitude is needed to extract the data within the water mask The minimum required parameters to construct the water level time series are: Time [decimal years], surface water elevations, track id, satellite id [if more than one mission is used]. A quality flag of the individual L2 water level measurement could be used as a weighting factor when reconstructing the water level time series.
Required auxiliary data	Water mask. A DEM may potentially be useful to detect erroneous measurements.

Maturity	Has been applied in several studies. A crude pre-filtering of the data must be implemented
Limitations	Currently not setup to run automatically for a global data set.
Reference	Nielsen, K., Stenseng, L., Andersen, O. B., Villadsen, H., & Knudsen, P. (2015). Validation of CryoSat-2 SAR mode based lake levels. Remote Sensing of Environment, 171, 162–170. https://doi.org/10.1016/j.rse.2015.10.023

2.10.L4 River Discharge (ATK, CNR, NUIM)

Table 2.10.1: Merging method to derive river discharge.

Required input parameters	L3 river water level.
Required auxiliary data	Reflectance products from Near-InfraRed images (MODIS, OLCI). The geometry of the section with information of width, depth and bottom is required but not indispensable.
Maturity	The algorithm used to combine altimetry and reflectance data was already applied in more than 20 sites in the range of 160 m to 3 km worldwide. The code is written in Matlab and in JavaScript (for Google Earth Engine application) and freely accessible under request.
Limitations	For completely ungauged river site the parameters of the algorithm cannot be calibrated, therefore their fixed values can induce not well accurate estimates of river discharge.
Reference	Tarpanelli A., Brocca L., Barbetta S., Faruolo M., Lacava T., Moramarco T. (2015) Coupling MODIS and radar altimetry data for discharge estimation in poorly gauged river basin. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 8(1), 141-148. doi:10.1109/JSTARS.2014.2320582. RIDESAT project - D3.2 Experimental Analysis.

Table 2.10.2: Rating curve approach to derive river discharge.

Required input parameters	L3 river water level.
Required auxiliary data	Simultaneous *in situ* river discharge at nearest gauge station.
Maturity	The algorithm is the baseline for daily discharge estimation at gauge stations (high maturity). Its successful adaptation to satellite altimetry is proven by numerous studies worldwide (medium maturity).
Limitations	For a completely ungauged river site the parameters of the algorithm cannot be calibrated. The accuracy of the altimetric L3 water height data is crucial.
Reference	Zakharova EA., Nielsen K., Kamenev G., Kouraev A., River discharge estimation from radar altimetry: Assessment of satellite performance, river scales and methods, Journal of Hydrology, 2020, 583, 124561.

Table 2.10.3: Bjerklie approach to derive river discharge.

Required input parameters	L3 river water level, L4 river water slope.
Required auxiliary data	River depth from auxiliary database, Dynamic river width from imaging satellite instruments In situ discharge (if the river depth is calibrated).
Maturity	The algorithm has been tested worldwide by different studies (medium maturity). The code is written in Matlab.
Limitations	The accuracy of the river depth estimate is crucial for successful discharge retrievals.
Reference	1. Bjerklie, D.M.; Dingman, S.L.; Vorosmarty, C.J.; Bolster, C.H.; Congalton, R.G. Evaluating the potential for measuring river discharge from space. *J. Hydrol.* 2003, *278*, 17–38. 2. Tarpanelli A., Barbetta S., Brocca L., Moramarco T. (2013) River discharge estimation by using altimetry data and simplified flood routing modeling. *Remote Sensing, 5*(9), 4145-4162.

Table 2.10.4: Manning approach to derive river discharge.

Required input parameters	L3 river water level, L4 river water slope.
Required auxiliary data	River depth from auxiliary database, Dynamic river width from imaging satellite instruments, Roughness parameter (tabular or calibrated), In situ discharge (if the roughness parameter is calibrated).
Maturity	The algorithm is tested on one site. Its modifications (MetroMan, GaMo - Durand et al, 2016) were tested on 16 world rivers (low maturity). The code is written in Matlab.
Limitations	The accuracy of the river depth estimate is crucial for successful discharge retrieval. An inaccurate guess of the roughness parameter can negatively affect the results.
Reference	1. Zakharova EA., Nielsen K., Kamenev G., Kouraev A., River discharge estimation from radar altimetry: Assessment of satellite performance, river scales and methods, Journal of Hydrology, 2020, 583, 124561. 2. Durand, M., Gleason, C.J., Garambois, P.A., Bjerklie, D., Smith, L.C., Roux, H., Rodriguez, E., Bates, P.D., Pavelsky, T.M., Monnier, J., Chen, X., Di Baldassarre, G., Fiset, J.-M.,Flipo, N., Frasson, R.P.D.M., Fulton, J., Goutal, N., Hossain, F., Humphries, E., Minear, J.T., Mukolwe, M.M., Neal, J.C., Ricci, S., Sanders, B.F., Schumann, G., Schubert, J.E., Vilmin, L., 2016. An intercomparison of remote sensing river discharge estimation algorithms from measurements of river height, width, and slope. Water Resour.Res. 52, 4527–4549.

3. Specification of input altimetry

3.1.Sentinel-3 SRAL (isardSAT)

Table 3.1.1: The Sentinel-3 SRAL data set.

Purpose	To provide altimetry measurements over in-land waters and coastal areas.
Geographic extent	Global (up to latitudes +/- 81.35º)
Temporal coverage	S3A (2016-current),. S3B (2018-current)

Source data	S3A & S3B L1A.
Reference	Sentinel 3 Product Data Format Specification L1 Ref.:S3IPF.PDS.003.1Issue:2.11Date:18 April 2018 https://sentinel.esa.int/documents/247904/2753172/Sentinel-3-Product-Data-Format-Specification-Level-1-products Sentinel 3 Product Format Specification: Product Structures Ref.:S3IPF.PDS.002; Issue:1.7, Date: 9 October 2017 https://sentinel.esa.int/documents/247904/1848151/Sentinel-3_Product_Format_Specification_Product_Structures

3.2.CryoSat-2 (isardSAT)

Table 3.2.1: The CryoSat-2 data set.

Purpose	To provide altimetry measurements over in-land waters and coastal areas.
Geographic extent	Global (up to latitudes +/- 88º)
Temporal coverage	2011-Current
Source data	CS2 FBR
Reference	CryoSat-2 Product Handbook: Baseline D. C2-LI-ACS-ESL-5319 Version: 1.1 Date: 13-DEC-201 https://earth.esa.int/documents/10174/125272/CryoSat-Baseline-D-Product-Handbook Cryosat Baseline-D Evolutions. Issue/Revision 1.0, Date of Issue 30/07/2018 (CryoSat Baseline-D Evolutions link) CRYOSAT Ground SegmentInstrument Processing Facility L1B Products Specification Format .CS-RS-ACS-GS-5106 Issue: 6.4 Date: 30/04/2015 https://earth.esa.int/documents/10174/125273/CryoSat-L1-Products-Format-Specification-v6.4.pdf CRYOSAT Ground Segment Instrument Processing Facility L1B CryoSat Ice netCDF L1B Product Format Specification. C2-RS-ACS-ESL-5364 Issue: 1.8 Date: 04/12/2018 https://earth.esa.int/documents/10174/125273/CryoSat-Ice-L1B-Product-Specification.pdf

4. Specification of auxiliary data

4.1. Coastal zone

4.1.1. Bathymetry and tidal model output (NOVELTIS)

Table 4.1.1a: Information about the GEBCO 2020 bathymetry dataset.

Purpose	To assess the ocean tide models in the coastal regions.
Geographic extent	Global
Temporal coverage	N/A
Availability	Public
Reference	GEBCO 2020 Bathymetry dataset GEBCO Compilation Group (2020) GEBCO 2020 Grid (doi:10.5285/a29c5465-b138-234d-e053-6c86abc040b9)

Table 4.1.1b: Information about the FES2004 ocean tide model.

Purpose	To assess the ocean tide models in the coastal regions.
Geographic extent	Global
Temporal coverage	N/A
Availability	Public
Reference	FES2004 global ocean tide model Lyard, F., Lefevre, F., Letellier, T., Francis, O., 2006. Modelling the global ocean tides: modern insights from FES2004. Ocean Dyn. 56, 394–415. https://doi.org/10.1007/s10236-006-0086-x

Table 4.1.1c: Information about the FES2012 ocean tide model.

Purpose	To assess the ocean tide models in the coastal regions.
Geographic extent	Global
Temporal coverage	N/A

Availability	Public
Reference	FES2012 global ocean tide model Carrère, L., Lyard, F., Cancet, M., Guillot, A., Roblou, L., 2012. FES2012: A new global tidal model taking advantage of nearly twenty years of altimetry. In: Benveniste, J., Morrow, R. (Eds.), Proceedings of the ‘‘20 Years of Progress in Radar Altimetry” Symposium, Venice, Italy, 24–29 September 2012, ESA Special Publication SP-710, 2012.10.5270/esa.sp-710.altimetry2012.

Table 4.1.1d: Information about the FES2014 ocean tide model.

Purpose	To assess the ocean tide models in the coastal regions.
Geographic extent	Global
Temporal coverage	N/A
Availability	Public
Reference	FES2014 global ocean tide model Carre`re, L., Lyard, F., Cancet, M., Guillot, A., Picot, N., Dupuy, S., 2015. FES2014: A new global tidal model, presented at the Ocean Surface Topography Science Team meeting, Reston, USA.

Table 4.1.1e: Information about the GOT4.10 ocean tide model.

Purpose	To assess the ocean tide models in the coastal regions.
Geographic extent	Global
Temporal coverage	N/A
Availability	Public
Reference	GOT4.10 global ocean tide model Ray, R. (1999). A global ocean tide model from Topex/Poseidon altimetry: GOT99.2, NASA Tech Memo 209478, Goddard Space Flight Center, Maryland, 58 pp.

Table 4.1.1f: Information about the DTU10 ocean tide model.

Purpose	To assess the ocean tide models in the coastal regions.
Geographic extent	Global
Temporal coverage	N/A
Availability	Public
Reference	DTU10 global ocean tide model Cheng, Y.. Andersen, O.B. (2011), Multimission empirical ocean tide modeling for shallow waters and polar seas. J. Geophys. Res. Ocean. 2011, 116, https://doi.org/10.1029/2011JC007172

Table 4.1.1g: Information about the EOT11a ocean tide model.

Purpose	To assess the ocean tide models in the coastal regions.
Geographic extent	Global
Temporal coverage	N/A
Availability	Public
Reference	EOT11a global ocean tide model Savcenko R., Bosch W., Dettmering D. Seitz F. (2012): EOT11a - Global Empirical Ocean Tide model from multi-mission satellite altimetry, with links to model results. PANGAEA, https://doi.org/10.1594/PANGAEA.834232

Table 4.1.1h: Information about the TPXO9 ocean tide model.

Purpose	To assess the ocean tide models in the coastal regions.
Geographic extent	Global
Temporal coverage	N/A
Availability	Public
Reference	TPXO9 global ocean tide model

	Egbert, Gary D., and Svetlana Y. Erofeeva (2002). Efficient inverse modeling of barotropic ocean tides, Journal of Atmospheric and Oceanic Technology 19.2, 183-204.

4.1.2. Coastal Proximity Data Set (SKYMAT)

Table 4.1.2: Information on the coastal proximity software.

Purpose	To test the performance of Sentinel-3 and CryoSat-2 by investigating their angle of approach towards the coastline.
Geographic extent	German Bight, Baltic German Coast, Gulf of Cadiz, Straits of Gibraltar, Harvest
Temporal coverage	
Availability	The software has been developed and applied.
Reference	SCOOP Product Validation Report (PVR), D2.5, Section 4.4

4.1.3. Fiducial (in situ sea level, waves, wind) (U Bonn, NOC, U Cadiz)

Table 4.1.3: Information about the fiducial data sets.

Purpose	To test the performance of the satellite geophysical parameters
Geographic extent	German Bight and South-Western Baltic Sea Harvest (US West Coast)
Temporal coverage	As needed
Availability	Public
Reference	https://www.psmsl.org/data/hf/ https://www.nodc.noaa.gov/BUOY/

4.2.Inland water

4.2.1. Digital elevation model for OLTC study (NOVELTIS)

Table 4.2.1a: Global DEM information for the OLTC study.

Purpose	To test the performance of CRYOSAT-2 regarding the acquisition of signal over hydrological targets
Geographic extent	Global coverage with medium accuracy
Temporal coverage	N/A
Availability	Public
Reference	SRTM/ACE2 Berry, P. A. M., Smith, R. G., & Benveniste, J. (2010). ACE2: the new global digital elevation model. In Gravity, geoid and earth observation (pp. 231-237). Springer, Berlin, Heidelberg.

Table 4.2.1b: Regional DEM information for the OLTC study.

Purpose	To test the performance of CRYOSAT-2 regarding the acquisition of signal over hydrological targets
Geographic extent	Regional coverage with high elevation accuracy
Temporal coverage	N/A
Availability	Public
Reference	ArcticDEM from the University of Minnesota Porter, Claire eta. 2018, “ArcticDEM”, https://doi.org/10.7910/DVN/OHHUKH, Harvard Dataverse, V1, [Accessed 10/06/2020].

4.2.2. SARIn off nadir range correction (DTU Space)

Table 4.2.2: Information about the SARIn off nadir range correction.

Purpose	To use the phase information from the two antennas to correct for off-nadir reflections and get the correct geolocation and range.
Geographic extent	Can be done everywhere where CryoSat-2 is in SARIn mode. Should not be done at too high angles, since the correction becomes too

	inaccurate.
Temporal coverage	
Availability	Algorithm already developed and implemented.
Reference	Armitage, Thomas & Davidson, Malcolm. (2014). Using the Interferometric Capabilities of the ESA CryoSat-2 Mission to Improve the Accuracy of Sea Ice Freeboard Retrievals. Geoscience and Remote Sensing, IEEE Transactions on. 52. 529-536. DOI:10.1109/TGRS.2013.2242082 CryoSat-2 product handbook: https://earth.esa.int/documents/10174/125272/CryoSat-Baseline-D-Product-Handbook

4.2.3. High Resolution Water Masks (ATK)

Table 4.2.3 Table: Information about the high resolution water mask.

Purpose	There is a need for two types of HRWM and if possible they should come from the same source data: Vector mask: To support the geo-selection of records over water, to select where to focus in SAR / FF-SAR modes, access the river width in support to the estimation of river discharge. Raster mask: To produce Water Fraction (WFR) data that may be useful to the end users (editing).
Geographic extent	ATK-HRWM: 5 zones of 100km x 100km @ 1 date per zone or any combination of num.Zones x num.Dates = 5 ; TP-HRWM (third party): upon access and quality (to be assessed if needed and instead of producing the masks).
Temporal coverage	Closely related to the Geographic Extent (see line above).
Availability	ATK-HRWM need to be produced. TP-HRWM to be tested (several options are available)
Reference	ATK-HRWM: Fabry et al. (2018). "The production of HR Water Masks with Sentinel-1, their verification with Sentinel-2 images and their use in Sentinel-3 Alti-Hydrology". In European Geosciences Union (EGU) General Assembly, 8-13 April, Vienna, Austria. Poster. TP-HRWM: - SWBD: the SRTM Water Body Data files are a by-product of the data editing performed by the National Geospatial-Intelligence Agency (NGA). Ocean, lake and river shorelines were identified

	and delineated. The product is available over a grid of tiles as vectors in ESRI 3-D Shapefile format : https://dds.cr.usgs.gov/srtm/version2_1/SWBD/ - GRWL: Global HRWM from Landsat images done by american SWOT team: https://zenodo.org/record/1297434#.XljQrihKhxc . Elena Zakharova has been using these masks and mentioned that these are static masks referred to the low level period when islands and sandbanks are exposed over the water table. She also mentioned that the raster masks are of good quality. The vector files are in fact vectorised river center-line of GRWL product and she found them less precise. The GRWL mask is the raster, so if we want to use it for extraction of altimetric measurements and river width for L3 and L4 products, it has to be vectorised. - There are many more databases.

4.2.4. Lake and river gauge hydrographic network (CNR-IRPI)

Table 4.2.4: River hydro-monitoring networks.

Purpose	To calibrate the parameters of the discharge algorithms and to test their performances
Geographic extent	Mississippi River Po River Danube River Red River Niger River
Temporal coverage	It depends on the sites, in the range 2002-present
Availability	Most of the sites are freely available. Niger River data are private and cannot be shared
Reference	GRDC (https://www.bafg.de/GRDC/EN/Home/homepage_node.html) USGS (https://www.usgs.gov/) ARPA (https://simc.arpae.it/dext3r/)

4.2.5. Reflectance products for river discharge (CNR-IRPI)

Table 4.2.5: Reflectance products information.

Purpose	To apply the integrated method to derive river discharge.

Geographic extent	Everywhere, based on the sites where the river discharge needs to be assessed. The coordinates of the selected sites will be used to extract the tiles of the datasets available (MODIS or/and OLCI or/and Landsat-8)
Temporal coverage	It depends on the availability of the altimetry data. MODIS dataset is available from about 2000 and it is ongoing; OLCI dataset is available from 2016; Landsat-8 dataset is available from 2013.
Availability	The reflectance products from MODIS and Landsat-8 datasets are freely accessible to all. For the OLCI products, the reflectance products need to be processed and made accessible.
Reference	MODIS: https://modis.gsfc.nasa.gov/ https://lpdaac.usgs.gov/products/mod09gqv006/ OLCI: https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci https://www.brockmann-consult.de/portfolio/climate-change/ Landsat-8: https://earthexplorer.usgs.gov/

4.2.6. Products related to inland water extent

Table 4.2.6a: Information about the Global Surface Water Explorer data sets.

Purpose	The product is based on Landsat imagery and contains the likelihood of water as a percentage with a pixel resolution of 30 m.
Geographic extent	Global
Temporal coverage	
Availability	Public. https://global-surface-water.appspot.com/download
Reference	Pekel, J. F., Cottam, A., Gorelick, N., & Belward, A. S. (2016). High-resolution mapping of global surface water and its long-term changes. Nature, 540(7633), 418–422. https://doi.org/10.1038/nature20584

Table 4.2.6b: Information about HydroSHEDS.

Purpose	A polygon layer shapefile mask of 1.4 million global distributed lakes.
Geographic extent	Global
Temporal coverage	

Availability	Public https://hydrosheds.org/
Reference	Lehner, B., Verdin, K., & Jarvis, A. (2008). New global hydrography derived from spaceborne elevation data. Eos, 89(10), 93–94. https://doi.org/10.1029/2008EO100001

Table 4.2.6c: Information about the GRWL Database.

Purpose	A line layer shapefile with river centerlines and information regarding the width of the river. Could be used for river width information and to determine angle of approach..
Geographic extent	Global
Temporal coverage	
Availability	Global River Widths from Landsat (GRWL) Database: https://zenodo.org/record/1269595#.XujDkc8zaUm
Reference	Allen, G. H., & Pavelsky, T. M. (2018). Global extent of rivers and streams. Science, 361(6402), 585–588. https://doi.org/10.1126/science.aat0636

5. Specification of test areas and in situ data

This section holds the proposed test and validation areas for work packages 2000 and 3000.

5.1.For validation of test data set

This section lists the various areas suggested for testing the algorithms reviewed in Section 2, i.e. these areas are to be used in WP2000. The areas have been chosen so that all climate zones and topography situations are represented. More information about each test area can be found in Appendix A.

5.1.1. Coastal zone

Table 5.1.1: Coastal zone areas proposed for testing the methods presented in Section 2 as a part of WP2000.

Target name	Country	Target type	In situ

Huelva	Spain	Coastal/Estuary	Water level
Tarifa	Spain	Coastal	Water level
Gulf of Cadiz	Spain	Coastal	None
Straits of Gibraltar	Gibraltar	Coastal	None
Baltic German Coast	Germany	Coastal	Water level
Elbe Estuary	Germany	Estuary	Water level, discharge

5.1.2. Inland water

Table 5.1.2: Inland water areas proposed for testing the methods presented in Section 2 as a part of WP2000.

Target name	Country	Target type	In situ
Po River	Italy	River	Water level, discharge
Mississippi River	USA	River	Water level discharge
Red River	USA	River	Water level, discharge
Danube River		River	Water level, discharge, GNSS
Niger River	Nigeria	River	Discharge
Amazon-Solimões River	Brazil	River	Water level
Rhine	Germany	River	Water level, discharge
Ob River	Russia	River	Water level, discharge
Yangtze River	China	River	Water level, discharge
Yellow River	China	River	Water level, discharge
Songhua/Amur	China	River	Water level, discharge
Pearl	China	River	Water level, discharge
Zambezi	Zambia	River	Water level
Nonacho	Canada	Lake	Water level
Reindeer Lake	Canada	Lake	Water level

Caspian Sea		Sea	GNSS
Java		Sea	GNSS

5.2.For Impact Assessment Use Cases

Once the most appropriate algorithms have been chosen, they will be used for a number of impact studies in WP3000. The studies will use the areas listed in the tables below.

5.2.1. Coastal zone

Table 5.2.1: Coastal zone areas proposed for validating the selected methods as a part of WP3000.

Target name	Country	Target type	In situ
Venice Lagoon	Italy	Coastal	Water level, waves, wind speed
German Bight	Germany	Coastal	Water level, waves, wind speed
Baltic Sea	Germany	Coastal	Water level, waves, wind speed
Bristol Channel/Severn Estuary	UK	Coastal/Estuary	Water level, discharge waves, wind speed

5.2.2. Inland water

Table 5.2.2: Coastal zone areas proposed for validating the selected methods as a part of WP3000.

Target name	Country	Target type	In situ
Po	Italy	River	Water level, discharge
Various lakes	Ireland	Lakes	Water level
Yakutian alasses	Russia	Lakes	Water level from altimetry
Watson	Greenland	River	Melt runoff
Kolyma	Russia	River	Water level
Nadym	Russia	River	Water level

Songhua/Amur	China/Russia	River	Water level, discharge bathymetry
Ebro Basin	Spain	River/lakes	Water level, discharge
Elbe	Germany	River/estuary	Water level, discharge
Rhine	Germany	River	Water level, discharge
Amazon Basin	Brazil	River	Water level, discharge
Mackenzie	Canada	River	Water level, discharge
Amour	Russia	River	Water level, discharge
Danube		River	GNSS
Caspian		Sea	GNSS
Java		Sea	GNSS, water level

6. Discussion

This document lists the various data sets and methods used for work packages 2000 and 3000. While the array of retracking and processing methods described in Sections 2 and 3 are expected to be mature and operational, the list of auxiliary data in Section 4 and the lists of test areas described in Section 5 are subject to change.

The list of auxiliary data in Section 4 might be extended, if new data sets are found within the course of the project. This might be due to any kind of improvement that is believed to be beneficial for the various studies.

7. List of Acronyms

ACE2 Altimeter Corrected Elevations (vers. 2)
AD Applicable Documents
AGC Automatic Gain Control
AH Alti-Hydro
AHP Alti-Hydro Product(s)
AI Action Item
AIM Action Item Management (tool)
AltiKa Altimeter in Ka band and bi-frequency radiometer instrument
AMSR-E Advanced Microwave Scanning Radiometer-Earth Observing System
ANA Agência Nacional de Águas (National Water Agency, Brazil)
AoA Angle of arrival
API Application Programming Interface
AR Acceptance Review
ASAP As Soon As Possible
ASCII American Standard Code for Information Interchange
ATBD Algorithm Technical Basis Document
ATK Along-Track S.A.S.
AVISO Archivage, Validation et Interprétation des données des Satellites Océanographiques
BIPR Background Intellectual Property Right
CASH Contribution de l'Altimetrie Spatiale à l'Hydrologie (Contribution of Space Altimetry to Hydrology)
CCN Contract Change Notice
CFI Customer Furnished Item
CLASS NOAA/Comprehensive Large Array-Data Stewardship System
CoG Centre of Gravity
CPP CryoSat-2 Processing Prototype (CNES)
CryoSat-2 Altimetry satellite for the measurement of the polar ice caps and the ice thickness
CRISTAL Copernicus polaR Ice and Snow Topography ALtimeter
CRUCIAL CRyosat-2 sUCcess over Inland wAter and Land
CSV Coma Separated Values
CTOH Centre de Topographie des Océans et de l'Hydrosphère (Centre of Topography of the Oceans and the Hydrosphere)
DAO Data Access Object
DARD Data Access Requirement Document
DDM Delay-Doppler Map
DDP Delay-Doppler Processor
DEM Digital Elevation Model
DGC Doppler Ground Cell
DPM Detailed Processing Model
DPP Data Procurement Plan
DTC Dry Tropospheric Correction
DTU Danmarks Tekniske Universitet (Technical University of Denmark)
DVT Data Validation Table
ECMWF European Centre for Medium-Range Weather Forecasts
ECSS European Cooperation for Space Standardisation
EGM Earth Gravitational Model
ENVISAT ENVIronment SATellite
EO Earth Observation
EOEP Earth Observation Enveloppe Programme
EOLi Earth Observation Link
EOLi-SA EOLi-Stand Alone
EPN EUREF Permanent Network
ERA ECMWF ReAnalysis
ESA European Space Agency
EUREF IAG Reference Frame Sub-Commission for Europe
FBR Full Bit Rate
FFT Fast Fourier Transform
FR Final Review
FTP File Transfer Protocol
FCUP (from portuguese) *"Faculdade de Ciências da Universidade"*, Science faculty of the University of Porto
GDAL Geospatial Data Abstraction Library
GDR, [I-,S-] Geophysical Data Record, [Interim-, Scientific-]
GFZ Deutsche GeoForschungsZentrum (German Research Centre for Geosciences)
GNSS Global Navigation Satellite System
GOCE Gravity field and steady-state Ocean Circulation Explorer
GPD GNSS-derived Path Delay

G-POD Grid Processing on Demand
GPT2 Global Pressure and Temperature model (vers. 2)
GPP Ground Processing Processor
GPS Global Positioning System
GRACE Gravity Recovery And Climate Experiment
GRDC Global Runoff Data Centre
GRGS Groupe de Recherche de Géodésie Spatiale (Space Geodesy Research Group)
GRLM Global Reservoir and Lake Monitor
GTN-L Global Terrestrial Network - Lakes
HDF-EOS Hierarchical Data Format - Earth Observing System
HGT A SRTM file format
HWS High Water Stage
HRWM High Resolution Water Mask
HYCOS Hycos Hydraulics & Control Systems
HYPE Hydrological Predictions for the Environment model
IAG International Association of Geodesy
IDAN Intensity-Driven Adaptive-Neighbourhood
IE Individual Echoes
IGS International GNSS (Global Navigation Satellite Systems) Service
IM Internal Meeting (e.g. not with the client)
IODD Input Output Data Document
IPF Integrated Processing Facility
ISD isardSAT
ITRF International Terrestrial Reference Frame
IRF Impulse Response Function
Jason-1 Altimetry satellite, T/P follow-on
Jason-2 Altimetry satellite, also knwon as the « Ocean Surface Topography Mission » (OSTM), Jason-1 follow-on
Jason-3 Altimetry satellite, Jason-2 follow-on
Jason-CS Jason Continuity of Service
KML Keyhole Markup Language
KO Kick Off
L1A Level-1A
L1B Level-1B
L1B-S, L1BS Level-1B-S (aka, Stack data)
L2 Level-2
L3 Level-3
L4 Level-4
LAGEOS Laser Geodynamics Satellite
LEGOS (french acr.) Laboratoire d'Études en Géophysique et Océanographie Spatiale (Laboratory for Studies in Geophysics and Spatial Oceanography)
LOTUS Preparing Land and Ocean Take Up from Sentinel-3
LPS Living Planet Symposium
LRM Low Resolution Mode
LSE Least Square Estimator
LWL Lake Water Level
LWS Low Water Stage
MARS Meteorological Archival and Retrieval System
MDL Minimum Description Length
MMSE Minimum Mean Square Error
MNDWI Modification of Normalised Difference Water Index
MoM Minutes of Meeting
MPC Mission Performance Centre
MRC Mekong River Commission
MTR Mid Term Review
MSS Mean Square Slope
MSS Mean Sea Surface
MWR Microwave Radiometer
NAVATT Navigation and Attitude
NDVI Normalised Difference Vegetation Index
NDWI Normalised Difference Water Index
netCDF Network Common Data Form
NOAA National Oceanic and Atmospheric Administration
NR New Requirement (w.r.t. the SoW)
NRT Near Real-Time
NWM Numerical Weather Model
OCOG Offset Centre of Gravity
OPC One per Crossing
OSTM Ocean Surface Topography Mission (also known as Jason-2), is also the name of the satellites series T/P, Jason-1, Jason-2 and Jason-3
OVS Orbit State Vector
PDF Probability Density Function
PEACHI Prototype for Expertise on AltiKa for Coastal, Hydrology and Ice
PEPS Sentinel Product Exploitation Platform (CNES)
PISTACH (french acr.) Prototype Innovant de Système de Traitement pour les Applications Cotières et l'Hydrologie
PMP Project Management Plan
POCCD Processing Options Configuration Control Document
PR Progress Report
PRF Pulse Repetition Frequency

PSD Product Specification Document
PTR Point Target Response
PVP Product Validation Plan
PVR Product Validation Report
PVS Pseudo Virtual Station(s)
PWF Pseudo Waveform
RADS Radar Altimeter Database System
RB Requirements Baseline (document)
RCMC Range Cell Migration Curve
RCS Radar Cross Section
RD Reference Document
RDSAR Reduced SAR (also known as Pseudo-LRM)
RF Random Forest
RGB Red, Green, Blue
RID Review Item Discrepancy
RIP Range Integrated Power (of the MLD) sometimes referred as Angular Power Response (APR)
RMS Root Mean Square
ROI (geographical) Region(s) Of Interest
RP Report Period (a month that is being reported into a Progress Report)
RSS Remote Sensing Systems
RWD River Water Discharge
RWL River Water Level
SAMOSA SAR Altimetry MOde Studies and Applications
SARAL In Indian "simple", in english "SAtellite for ARgos and AltiKa.
SARIn SAR Interferometric (CryoSat-2/SIRAL mode)
SAR Synthetic Aperture Radar
SARvatore SAR Versatile Altimetric Toolkit for Ocean Research & Exploitation
SCOOP SAR Altimetry Coastal & Open Ocean Performance
SDP Software Development Plan
SEOM Scientific Exploitation of Operational Missions
SHAPE Sentinel-3 Hydrologic Altimetry PrototypE
SI-MWR Scanning Imaging MWR
SME Small and Medium-sized Enterprise
SMHI Swedish Meteorological and Hydrological Institute
SNAP SeNtinel Application Platform
SOA State Of the Art
SOW Statement Of Work
SPR Software Problem Reporting
SPS Sentinel-3 Surface Topography Mission System Performance Simulator
SRAL SAR Radar Altimeter
SRTM Shuttle Radar Topography Mission
SSB Sea State Bias
SSMI/IS Special Sensor Microwave Imager (SSM/I) Sounder
SSO Single Sign-On
Stack Matrix of stacked Doppler beams
STD Standard Deviation
STM Sentinel-3 Surface Topography Mission
SUM Software User Manual
SWBD SRTM Water Body Data
SWH Significant Wave Height
TAI Temps Atomique International (International Atomic Time)
TBC To Be Confirmed
TBD To Be Done
TCWV Total Column Water Vapour
TDS Test Data Set
TMI Tropical Rainfall Measuring Mission (TRMM) Microwave Imager
TN Technical Note
T/P Topex/Poseidon (altimetry satellite)
TR Technical Risk
UNESCO United Nations Educational, Scientific and Cultural Organization
URL Uniform Resource Locator
USGS United States Geological Survey
USO Ultra Stable Oscillator
UTC Coordinated Universal Time
UWM Updated Water Mask
VS Virtual Station(s)
VH Vertical-Horizontal polarisation
VV Vertical-Vertical polarisation
WBS Work Breakdown Structure
WF Waveform
WFR Water Fraction Ratio
WMO World Meteorological Organization
WP Work Package(s)
w.r.t. with respect to
WTC Wet Tropospheric Correction
XML eXtensible Markup Language
ZP Zero Padding