Coastal Erosion from Space

Annex 2 – The Processors

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1 Version and Signatures

Version	Date	Modification
Verification by		
Authorisation		

2 Acronyms

3 Applicable and reference documents

Id	Description	Reference
AD-1	Requirement Baseline Document	SO-RP-ARG-003-055-006-RBD_v1.0_20190916
AD-2	Technical Specification Document	ARG-003-055-009-TSD

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1 The Processors

1.1 Pre-Processing

Service Provider	AdwaisEO/ARGANS
Description: Data Collection	
• To provide a system of collecting, formatting and storing of all EOs and auxiliary datasets. • Data must be assigned an appropriates identification nomenclature so that it can be easily accessed by automatic processors.	
Outputs	
• System/Pre-Processor ready EO and Auxiliary data	
Outstanding Risks	
• Various formats and datums within end-users' Auxiliary Datasets. • Availability of relevant Auxiliary Data • Definition of storage capacity requirements.	
Description: Pre-Processing	
• To provide an automatic pre-processing platform that prepares all EO products for CSI extraction by EO Processors (Section 5.1). • Co-register each EO image based on orthorectified master images that are geo-located. (All products) • Re-sample image to required spatial resolution. (All products) • Cloud masking. (Selected products) • Glint correction. (Selected products)	
Outputs	
• Processor ready EO products	
Outstanding Risks	
• While the pre-processing processor is still in development, production will continue and may require post processing correction (co-registration etc).	
Verification Process	
• Visual comparison between co-registered images	

1.2 Foundation Processors

1.2.1 Waterline Identification (VNIR)

Service Provider	ARGANS
Description:	
• Automatic detection of the boundary between the sea and the land surface during each EO observation by optical satellites (Positions C in Figure 2.1), correcting from errors due to seaward whitecaps (wave breaking) • Product should be completed run with all optical EO platforms including Sentinel 2, Landsat and all commercial satellites (VHR).	
Outputs	
• CE_ARG_area_L2_1D_OB_WL_sensor_date.shp	• CSI Position: Proxy based waterline
Outstanding Risks	
• Work needs to be completed to convert the code to accept Landsat and non-Maxar VHR data (e.g. Pleiades and SPOT) • No error budget = uncertainty equation to be developed • Verification and Validation testing	
Auxiliary Data Requirements	
• Sampling rate definition • Wave fields offshore and local winds • Shore slope • Upper beach' and lower beach's materials (+ their VNIR spectra)	
Verification process	
By eye comparison between the computed line and a VHR images	

1.2.2 Waterline Identification (SAR)

Service Provider	IsardSAT
Expert User	BGS
Description:	
• Automatic detection of the boundary between the sea and the land surface. (Position C in Figure 2.1)	

Outputs	
• CE_ISR_**area**_L2_1D_OB_WL_**sensor_date**T**time**.shp	• CSI Position: Proxy based waterline (SAR)
Outstanding Risks	
• Initial development is complete, however the ability to run on various SAR missions is unclear • Signal noise from geometric distortion from tall objects adjacent to shore need to be accounted for. • Error budget and uncertainties are unknown at present	
Auxiliary Data Requirements	
• Sampling rate to be defined • Wave fields offshore and local winds • Beach humidity profiles • Shore DTM	
Verification process	

1.2.3 Mapping/Feature Classification

Service Provider	ARGANS		
Expert User	ARCTUS		
Description:			
• Automatic land cover classification of the coastline, including the littoral zone and backshore area in the immediate vicinity to the seafront (Littoral Limit). • Classification provides information to derive the boundary between Littoral zone and Backshore (Zones 1 and 2 respectively in Figure 2.1), as a boundary described as the Littoral Limit (Positions A in Figure 2.1).			
Outputs			
• CE_ARG_**area**_L2_1D_FB_LL_**date**.shp		• CSI position: boundary between the Littoral Zone and the Backshore, derived from classification map from a single EO sample.	
• CE_ARG_**area**_L2_1D_FB_SF_**date**.shp *an intermediary product*		• Classification map of land cover types and ecosystems from a single EO sample.	
• CE_ARG_**area**_L3_1D_FB_LL_**date_date**.shp		• Mean-position CSI: boundary between the Littoral Zone and the Backshore from classification maps built from multiple EO products from the same satellite mission.	

• CE_ARG_**area**_L3_2D_FB_LULC_**sensor_date_date-**.tif	• Classification map: land cover types and ecosystems derived from a combination of multiple EO observations during a given period (season)
Current Status:	
• The processing is done by the IOTA^2 platform, which is system ready.	
Outstanding Risks	
• The methodology is not completed (choice of training data sets for the random forest algorithm): for each case study area, a training dataset needs to be completed, and its validity in time is not known. • A short programme needs to be developed to create a binary image out of the classified image (littoral zone and backshore). ○ This should be done automatically and parameterised by the different environments longshore. • No error budget (except a posteriori estimates) = uncertainty equation to be developed • Verification and Validation testing datasets required.	
Auxiliary Data Requirements	
• Sampling rate definition • Tidal data • Validation data (i.e. positions of seafront at given observation periods).	
Verification data	
Process validation statistics for accuracy and precision (Overall accuracy and Kappa Coefficient)	

5.1.2 Satellite Derived Bathymetry

Service Provider	ARGANS
Expert User	GSI
Description:	
• To inform on sediment transport and nearshore run slope characteristics, satellite derived bathymetry will be applied to produce a 3D DTM of the nearshore. (Zone 2 in Figure 2.1)	
Outputs	
• CE_ARG_**area**_L2_3D_BT_SDB_**sensor_date**.tif • CE_ARG_**area**_L3_3D_BT_SDB_**sensor_date_date**.tif •	• DSM/ Digital Surface Model which captures natural and built features

• CE_ARG_**area**_L2_3D_BT_BP_**date** derived product from the formers using • [EO]-L2_3D_BTM/SDB/m_{area/date/hour} [Alg(L2)] • [EO]-L3_3D_BTM/SDB/m_{area/date/hour-[Δt]} [Alg(L3)] • [EO]-L3_3D_BTM/SDW/m_{area/date/hour-[Δt]} [Alg(L3)] • L4_3D_BTM/SDW/m_{area/date/hour-[Δt]} [Alg(L4)] • [EO]-L3_3D_BTM/SDB/m_{area/date/hour-[Δt]} [Alg(L3)] • L4_3D_BTM/SDB/m_{area/date/hour-[Δt]} [Alg(L4)]	• Cross shore profile: Slope characteristics at defined transect positions. products whose design is under consideration
• ADFs of [EO]-L2_3D_BTM/…_{area/date/hour-…} [Alg(L2)]	• Difference assessment: comparison of nearshore morphology between reference data (e.g. chart data) and optical SD
• CE_ARG_**area**_L4_3D_BT_SDB_WF_**sensors_date_date**.tif • L4_1D_BTM/m_{area/date/hour-[Δt]} }[Alg(L4)]	• Fusion of BTM information from optical and SAR images: depths & slopes products whose design is under consideration
Outstanding Risks	
• SDB is only suitable for certain conditions (atmospheric, hydrodynamic, geometric), suitability for each site will become apparent during data production. • processors b., c. and d. might not be ready for end Y2019.	
Auxiliary Data Requirements	
• Depth of closure information (to be provided by users), to define the seaward limit of area of interest. • Reference surveys. • Tide gauge/ tidal data. • Atmospheric pressure. • Wavefield (wind waves and swell) as well as wind data. • Sampling rate definition	
Verification Process	
• Comparison with existing nautical chart	

5.1.3 5.2.5 Wave Field Analysis

Service Provider	IsardSAT
Expert User	GSI
Description:	

• To produce information from wave field patterns in the nearshore, deriving information on the seafloor based on changing sea-waves' wavelength, and waves' breaking. • Describe the shoaling areas, including type of breakers and length of shoaling areas, thus informing on the type/angle of slope in the beach run-up. (Zone 2 in Figure 2.1)	
Outputs	
• CE_ISR_**area**_L2_3D_BT_WF_**sensor_date**.**XXX** • CE_ISR_**area**_L3_3D_BT_WF_**sensor_date_date**.**XXX**	• Feature recognition: identify anomalies when comparing wave fields in the shoaling zone compared to theoretical wave fields for standard seabed (reference data from chart / DEM-DTM), locate bars & shoals; • Gross estimate of beach face slope; • Assess depth over bars and shoals products whose design is under consideration
Outstanding Risks	
• To be updated	
Auxiliary Data Requirements	
• Reference chart data. • Wavefield (wind waves and swell) as well as wind data. • Tidal data. • Atmospheric pressure. • Sampling rate definition.	
Verification process	
•	

1.3 Data Fusion Processors

1.3.1 Shoreline Extrapolation/ Extraction

Service Provider	ARGANS
Expert User	IHC
Description:	
• To transform all waterline observations into datum-based shoreline indicators between mean-high-water mark (MHWM) and mean-low-water mark (MLWM) (Positions B.1 to B.2 in Figure 2.1).	

Nota: for this phase of the ESA contract, we won't use hydrographic or cartographic astronomical tide-level datum such as HAT, MHWS, MHWN, OHWS, HWMOT, HWMOST, HWMMT, MHW, DTL-MTL, MLWS, MLWN, LWMOT, LWWMMT, LWH, LWMOST, and LAT[1], but the MHWM and MLWM which looks more appropriate to coastal erosion assessment, though MHW and LHW are used by the Ordnance Survey agency and BGS.

- Transformations will be based on the position of waterline in reference to a known slope angle of beach run-up and an accurate understanding of sea state at point of observation (tide height, wave setup).

Outputs

• CE_ARG_area_L2_1D_DB_SL_MHWM_date.shp • CE_ARG_area_L2_1D_DB_SL_MSWM_date.shp • CE_ARG_area_L2_1D_DB_SL_MLWM_date.shp • CE_ARG_area_L3_1D_DB_SL_MHWM_date_date.shp • CE_ARG_area_L3_1D_DB_SL_MSWM_date_date.shp • CE_ARG_area_L3_1D_DB_SL_MSL_date_date.shp • CE_ARG_area_L3_1D_DB_SL_MLWM_date_date.shp	CSI Position: Datum based tidelines

Outstanding Risks

- because the slopes vary between the beach face, the position of the waterline on each EO, and the location of the shoreline based on tide-level datum, one should choose waterlines that are near the expected shorelines = waterlines drawn from EO snapshots taken at similar tidal coefficients[2] compared to the tide-level datum coefficient.
- Cross-shore profiles to be extracted from SDBTM products, or to be introduced as external auxiliary data.

[1] HAT: highest level that can be expected to occur under average meteorological conditions and under any combination of astronomical conditions; MHWS/ MHWN: average of the two successive high waters during those periods of 24 hours when the range of the tide is at its greatest/least; OHWS: ordinary high water springs and HWMOST, i.e. high water mark of ordinary spring tides; MHW: Mean High Water and HWMOT, i.e. high water mark of ordinary tides; HWMMT: high water mark of medium tides; DTL: arithmetic mean of mean higher high water and mean lower low water; MTL: arithmetic mean of mean high water and mean low water; MLWS/MLWN: average of the two successive low waters during those periods of 24 hours when the range of the tide is at its greatest/least; LHW: mean low water and LWMOT, i.e. low water mark of ordinary tides; LWWMMT: low water mark of medium tides; OLWS: Ordinary low water Spring, and LWMOST, i.e. low water mark of ordinary spring tides; and LAT: lowest level that can be expected to occur under average meteorological conditions and under any combination of astronomical conditions;

[2] $c = \left(\left(h_h - h_l \right) / \Delta h \right) \cdot 100$ where h_h is the depth at the nearest high water time, h_l the depth at the nearest low water time, and $\Delta h = h_h - h_l$

• To be corrected from the wave set-up, that requires information on the wave field spectrum, the waves direction, and the bathymetry (to model the water piling up on the shore, yet escaping laterally by alongshore currents)
Auxiliary Data Requirements
• Waterlines (proxy) • Beach slopes r cross-shore profiles • Tidal data. • Wavefield, wind and swell data. • Atmospheric Pressure data
Verification process
•

1.3.2 Stochastic Estimation of Erosion Rates

Service Provider	ARGANS
Expert User	All partners
Description:	
• To provide information on CSIs position change (Positions A, B.1 to B.2 in Figure 2.1). • To give estimation of sediment volume change from evolution of the cross-shore profile within defined cells longshore.	
Outputs: time series of shoreline models, and estimates of erosion rates	
• [EO]-L3t_1D_FB_OHWM-VL_{area/date/hour-[Δt]} [Alg(L3t)] • L4t_1D_FB_OWHM-VL_{area/date/hour-[Δt]} [Alg(L4t)]	• change detection: comparison of shorelines (proxy) from same EO mission or different EO missions
• *[EO]-L3t_1D_DB/[tide level]-SL_{area/date/hour-[Δt]}* *[Alg(L3t)]* • *L4t_1D_DB/[tide level]-SL _{area/date/hour-[Δt]}* *[Alg(L3t)]* • [EO]-L3t_1D_DB/CSL_{area/date/hour-[Δt]} [Alg(L3)]	• estimate of motion of shorelines (datum) and calculation of related volume changes, using shoreline profiles from the same EO mission or different EO missions.
• [EO]-L3t_3D_BTM/SDB_{area/date/hour-[Δt]} [Alg(L3t)] • L4t_3D_BTM/SDB-SDS-_{area/date/hour-[Δt]} [Alg(L3t)]	• estimation of cross-shorelines' volume changes
Outstanding Risks	
• "filtering"/adjustment of all data sets which are stacked in a time-series of period Δt, to have consistent shorelines and bathy-morphology models for the calculation of erosion rates on stationary cross-shore profile at δt time scale.	

• error budges to be devised.
Verification process

1.3.3 Post Processing

Service Provider	ARGANS /Adwaiseo
Description:	
• Metadata collection and product file construction • To collate all information that characterises the coastline in each EO product delivery. • This information will be delivered as instantaneous information for 2D products (e.g. weather, tide and sea state conditions) • Metadata information on the EO product(s) used to derive the products will also be provided. • An error estimation will be generated and included with each product. • Each product will be assigned a specific file ID that allow instant access through database indexing.	
Outputs	
• EO product indexing ID. • Auxiliary data table, including metadata and error estimation if errors are not in the file bundle	
Outstanding Risks	
• N/A	
Verification Process	

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