



Coastal Erosion from Space



CCN2 - Final Report (December 2022 to June 2023)

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Date: 20/06/2023

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Coastal Erosion from Space
Final Report

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Page :ii

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Acronyms

BGS	British Geological Survey
CESBIO	Centre d'Etudes Spatiales de la Biosphère
ESA	European Space Agency
EO	Earth Observation
FTP	File Transfer Protocol
GSI	Geological Survey Ireland
HR	High Resolution (EO data)
IHC	Environmental Hydraulics Institute, IH Cantabria
ISPRA	Italian National Institute for Environmental Protection & Research
KO+#	Kick Off (+number of months (#))
LPS	Living Planet Symposium
LULC	Land Use Land Cover
MoM	Minutes of Meeting
MS	Milestone number
PM#	Progress Meeting number
PVP	Product Validation Plan
RBD	Requirements Baseline Document
SAR	Synthetic Aperture Radar
SDB	Satellite Derived Bathymetry
TO	Technical Officer
TSD	Technical Specifications Document
URD	User Requirement Document
VNIR	Visible and Near-Infrared
VHR	Very High Resolution (EO data)
WP	Work Package



SIGNATURES	1
ACRONYMS	2
EXECUTIVE SUMMARY	7
1 INTRODUCTION	11
1.1 PROJECT OVERVIEW.	11
1.2 THE POTENTIAL CONSUMERS.	13
1.3 THE CONSORTIUM	14
2 SUMMARY OF DELIVERABLES	17
2.1 CONFERENCE AND PUBLICATIONS	17
2.2 THE TUTORIAL	22
2.3 THE BROCHURE	23
2.4 THE MEDIA APPROACH	24
3 FOLLOW ON TASKS	27
3.1 GLOBAL DEVELOPMENT ASSISTANCE – DISASTER RESILIENCE (GHANA COAST)	27
3.2 OPEN CLOUD RESEARCH ENVIRONMENT SUPPORT TO MAINLAND GREAT BRITAIN SHORELINE PROJECT (OCRE-GB)	30
3.3 UK TASKS DERIVED FROM OR ASSOAIATED WITH COASTAL EROSION FROM SPACE	32
3.4 UKSA ENABLING TECHNOLOGY – A GLOBAL CAPABILITY TO SUPPORT DEVELOPING NATIONS.	34
4 OVERALL SUMMARY	36
4.1 COVERAGE DURING THE PROJECT	36
4.2 PLATFORM OPPORTUNITIES	39
5 CONCLUSION & RECOMMENDATIONS	40



5.1	THE KEY POINTS-----	40
5.2	LESSONS IDENTIFIED/RECOMMENDATIONS. -----	40

List of Figures

Figure	Description	Page
Figure 1:	Global coastal products coverage	10
Figure 2:	Cliff erosion, Quebec (Canada)	11
Figure 3:	37th International Conference on Coastal Engineering	17
Figure 4:	GEO Blue Planet 5th Symposium	17
Figure 5:	OCRE Final Review Conference, Lisbon Dec 22.	18
Figure 6:	EGU General Assembly, Vienna	18
Figure 7:	IHO 3rd General Assembly, Monaco.	19
Figure 8:	GEO Business 2023, London	19
Figure 9:	UK Coastal Research Conference, July 2023, Plymouth	20
Figure 10:	ARGANS/BGS presentation to UKCRC, Plymouth	21
Figure 11:	The four language EO for Coastal Management Tutorials	22
Figure 12:	Tutorial acknowledgements	23
Figure 13:	Protecting Your Coastline brochure front page.	23
Figure 14:	brochure inside pages	24
Figure 15:	SciAni Animated marketing of Coastal Erosion from Space for YouTube.	24
Figure 16:	WOD article for New Scientist.	25
Figure 17:	BBC Coastal Erosion home page	26
Figure 18:	ARGANS presenting on local news channel.	26
Figure 19:	Left: evolution of the shorelines in the study area in different moments. Right: identification of erosion and accretion zones after calculation of changes across time series.	29
Figure 20:	2015 - 2021 MSL shoreline time series for Keta region	30



Figure 21: OCRE-GB Project front page	30
Figure 22: Mainland GB full coastline coverage	32
Figure 23: coastline types observed.	36
Figure 24: Structural and morphological description of the study sites	36
Figure 25: Irish demonstration sites	37
Figure 26: Spanish demonstration sites	37
Figure 27: Quebec demonstration sites	38
Figure 28: GB demonstration sites	38
Figure 29: Italian demonstration sites	39
Figure 30: OCRE Catalogue for Coastal Erosion Services	39

Executive Summary

[HTTPS://coastalerosion.argans.co.uk](https://coastalerosion.argans.co.uk)

The Coastal Erosion from Space project, 4000126603/19/I-LG, was commissioned under the Science for Society slice of the 5th Earth Observation Envelope Programme (EOEP-5) of the European Space Agency. The purpose of the Coastal Erosion Project was to raise the societal profile of EO derived products, and the professional profile, i.e., to push for the adoption of EO products as a coastal survey means by field surveyors and their patrons (the coastal management authorities, at the international, national, regional or local level, and their civil engineering contractors) as well as by scientists (i.e., the wider community). At the conclusion of the 2-year project an additional years Contract Change Notice (CCN) was awarded which looked to add additional mileage to coastal coverage and bring in an additional nation to the consortium. On conclusion of the 3-year project and the publication of the final report a second short 6-month CCN was issued to enable a media outreach campaign to be conducted. The open version of the Coastal Erosion from Space Final Report can be discovered at the link below.

https://eo4society.esa.int/wp-content/uploads/2022/09/SO-RP-ARG-003-055-FINAL-REPORT_CCN_OPEN_version.pdf

This report identifies the activities undertaken to “get the message” out about the successful muse of Earth Observation to help coastal management decision making.

The approach by ARGANS adopted a multi-layer strategy which looked at a news release for mainstream media, publishing on social media, attending suitable conferences, designing some marketing material including an article to be included within a widespread scientific journal, developing an animated short feature, appearing on TV and delivering a “tutorial” which could be translated into the languages of the consortium partners.

The message was clear, over 7,300km of coastlines have been observed across 21 differing sites in 5 nations to demonstrate that the innovative techniques developed are truly scalable worldwide and are ready NOW to be contracted for by any nation.



What also became clear very early in the CCN was that mainstream media despite covering coastal erosion (ie the BBC's coverage <https://www.bbc.co.uk/news/topics/c6gzdpk9ggkt>), were not particularly interested in the scientific approach and evidence gathering and this led to our campaign shifting to relying on social media such as Linked-In to reach potential customers and interested individuals.

ARGANS Limited and its partners have now reached the end of the three-and-a-half-year project funded by the Science for Society slice of the 5th Earth Observation Envelope Programme overseen by ESA/ESRIN (the European Space Agency/Space Research Institute) which commenced 3 April 2019. The partnership consisted of a EO based information service provider group of Earth Observations and Data experts comprising ARGANS Ltd (UK/Fr), isardSAT (Spain) and adwaisEO (Luxembourg) who delivered to an authoritative public User Group of national representatives from the British Geological Survey, the British government experts, IH Cantabria in Spain on behalf of the Spanish government's Ministerio para la Transición Ecológica y el Reto Demográfico (MITECO), Geological Survey Ireland, the Irish Government experts and ARCTUS representing the Canadian academic world and the local communities of Québec. For the initial CCN an additional national expert from Italy was added to the consortium, namely the Italian National Institute of Environmental Protection and Research.

The consortium has developed a method to optimise the number of customer ready co-registered waterlines and datum referenced shorelines seasonally covering 25 years that have been validated by the leading technical geomorphological experts within the five partners' nations. These products deliver inter-pixel accuracy, use a locally adaptive threshold method to accurately determine the position of the land/sea boundary precisely and can be scaled to cover complete nations worldwide. Indeed, each partner nation intends to continue this work to provide national coverage. We have developed a land classification map that describes the coastal strip, including coastal features and their inter-annual changes which enable beach width to be determined. Boundaries have been pushed using satellite derived bathymetry techniques based on a long history of this technology to observe features of interest even in the sediment laden waters.



Product Scope: Over **7300km** of coast analysed across 5 nations (Great Britain, Republic of Ireland, Spain, Italy and Canada (the Province of Quebec)), spanning over 25 years of satellite imagery.

Follow on Scope: Not delivered under this project but made possible due to the technologies developed were an additional 205Km of coast analysed in Ghana under the GDA-DR project, and an additional over **15,400km** coast covered in Great Britain under the OCRE-GB project.

Expert Analysis: Products validated by coastal experts from leading national institutions.

Global Outreach: 5 workshops and webinars have been delivered, over 10 conferences including Living Planet Symposium, national Geospatial and Coastal Engineering events have been presented.

Impactful Research: Peer-reviewed paper published with several papers are under preparation to be submitted to leading high-impact journals.

Social Media Campaign: Firstly, with **MediaPlanet** via a special World Oceans Day copy of the New Scientist and then with **SciAni**, a company that creates animations to better explain science for social media campaigns.

The **Coastal Erosion from Space** Project has certainly demonstrated the value of Copernicus EO data and Landsat mission to derived products to monitor multi scale coastal change in various geomorphological environments. The feasibility phase had wide-reaching stakeholder engagement to capture the requirements of both industry, institutes, and government, local and national. During the initial CCN many of these requirements were revalidated alongside the experienced gained to date by the lead national institutions, their associated partners in both local and national government agencies and departments. The initial project delivered a period of design and development to manufacture of a range of products that have been improved during the first CCN. These products have a global applicability to help coastal managers better understand their areas of responsibility and also enable them to plan how they will mitigate the effects of coastal change. Another key tenet of the first CCN has been to move the knowledge threshold from geospatial data products to information of utility to those decision makers responsible for coastal management.

Finally, the second CCN has seen a growth in social media presence, more attendance at conferences but perhaps most critically the skills and experienced gained has also been translated into new projects and proposals.

Coastal Erosion - Studied Sites

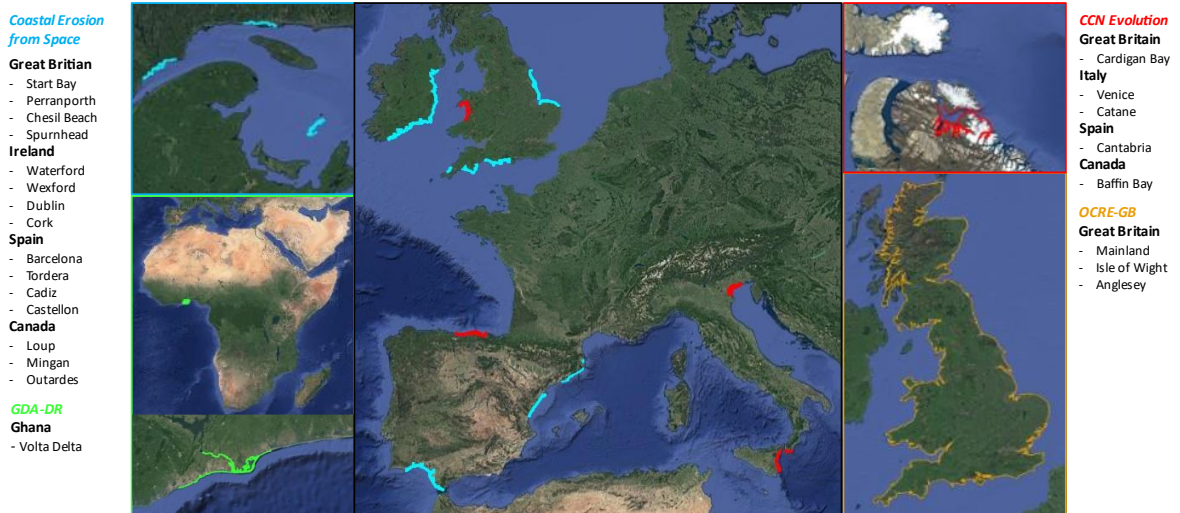


Figure 1: Global coastal products coverage

1 Introduction

1.1 Project Overview.

1.1.1 The Project.

The Coastal Erosion from Space project, 4000126603/19/I-LG, was commissioned under the Science for Society slice of the 5th Earth Observation Envelope Programme (EOEP-5) of the European Space Agency. The Statement of Work set the challenge to aim at developing innovative EO products and methods in response to authoritative end-user requirements. A further Contract Change Note was awarded in September 2021 with the aim including an additional expert institution from a new country and updating the delivered key coastal state indicators products to the present. As will be demonstrated throughout this report, the relationship between the authoritative professional and technical User Group brought together under the Coastal Change Consortium and the Service Provider Group has been instrumental to ensuring valuable products tuned to the user need have been developed and delivered and the addition of ISPRA has been very good fit. A second Contract Change Note was awarded in October 2022 with a main objective being to raise the profile of the work conducted so that additional contracts and new customers might be identified.



Figure 2: Cliff erosion, Quebec (Canada)

The project was initially funded for 2 years and was split into two phases. On completion a CCN was awarded for an additional single phase, one year period, ie phase three. **The first phase** enabled the User Requirements to be collated and then for them to be refined into the art of the possible based on the existing and archive technologies and the innovative approaches that could be developed within this feasibility phase. **The second phase** moved to implementation where both production and validation became the key tasks. Alongside this work were two additional requirements placed upon the consortium, namely, to develop a pilot data access service and also to broadcast the range of new products, their development, validation and utility via a series of workshops hosted in the four participating nations. The initial plan had been to host these as live events within the partner institutions; however, the onset of the global COVID-19 pandemic required these events to become virtual. This approach proved most popular with in excess of 600 delegates attending the events. **The third phase** (the first CCN) supplemented the user requirement based on lessons identified and feedback from the workshops. This phase provides an additional 1500km of coastal products, updated all the previous sites' products to mid-2022, added an additional nation (Italy) to the consortium and delivered improved capabilities as well as an additional workshop, this time more focused on the decision makers in local and national government as well as heads of institutions connected with coastal management. **The additional final phase** introduced a heavy slant toward a media campaign to educate a wider audience as to the utility of employing Earth Observation to help coastal management decisions and expenditure.

1.1.2 An Outreach Strategy

A short study was commenced at the beginning of the CCN drawing evidence gathered during the previous workshops and based on additional projects that have been enabled from the **Coastal Change from Space project** outcomes. It was recognised that the main objective of this short CCN is to inform as wide an audience as possible about the value that Earth Observation techniques can bring to those who work in the coastal domain and the following groups were identified. Policy makers and decision takers at the national level or at the practical application level of coastal management which is normally devolved to the regional or local/municipality level were the first and major group. In addition, other institutes and academics that advice government bodies also have an interest. A third sector identifies are those coastal engineering

and construction/development companies engaged in coastal infrastructure, however often they rely on direction from their employer, the government bodies who commission works. A fourth group has also been identified and those are the International Financial Institutions who are beginning to be more evidence based or biased in how they offer loans or expect loans to be spent when focused on coastal development, risk reduction and resilience. To meet the requirement to engage with all these groups a multi-strand approach was followed which sought to gain mainstream media coverage, attended conferences and professional trade exhibitions backed by social media campaigns mostly via Linked-In (as this was advised by two media companies as the best option).

1.2 The Potential Consumers.

During the previous phases of the Coastal Erosion from Space project, the emphasis on any outreach opportunity always had a scientific or immediate (ie institutional) focus and although marketing is never far away from daily operations for an SME, that focus was naturally on consortium partners and their stakeholders. The new way of working, following the global pandemic COVID-19, added some challenges. It has very much been a transition to tele-networking and virtual conferences and workshops supported by papers. However, over the course of the complete project lifespan a few live events have been attended and presented at including the Living Planet Symposium 2022 and GEO Business 2022 & 2023. A fuller picture is included later.

The mandated workshops in phase 2 provided an excellent opportunity though to showcase the project, the products, the utility of the Sentinel Mission as well as providing an excellent vehicle to engage with decision makers, planners and academics working in this field, with an additional workshop delivered that featured a panel discussion of experts from local and national government, heads of institutions and space agencies during the first CCN. The theme was to explore the knowledge and uptake and utility for decision makers.

With all this evidence gathered it became clear as we developed relationships with local, regional and national coastal managers that Earth Observation was a known technology but not very well

exploited. It also became apparent that the market for Earth Observation coastal erosion products and services was very much likely to be within government agencies and departments. The state institutions are definitely the “technical advisers” to government and the decision to partner with these institutions appears to be applicable globally.

It was hoped that coastal engineering and construction companies may have an interest however the workshops suggested that such companies have a very narrow focus on delivering a very local solution as directed under contract from local, regional or national governments.

During this period, however one more “quasi” government like group did emerge as potential customers and consumers of coastal erosion products derived from satellites and that is the International Financial Institutions (IFI). During the course of another ESA project (more of which later under follow on tasking generated by this project) it became clear that institutions such as the World Bank Group and specific departments/programmes within the WBG such as the West Africa Coastal Areas (WACA) Management Programme are also interested as they view such evidence as a supportive of the loans they might offer to developing nations who are looking to develop and protect their coastlines.

With such customers in mind the design and development of brochures and tutorials explaining how Earth Observation can help has been extremely timely and useful.

Finally, the <https://coastalerosion.argans.co.uk> website is another avenue to explore the project and housed within this website is the Data Access Portal which was delivered in phase 2 to enable the products to be accessible via a webservice to those authorised.

1.3 The Consortium

For our project **five nations** were engaged building a trusted relationship with those institutions who are vested with the responsibility to advise their national systems. In addition, **over 7000 linear km** of coastline has been observed over 21 different sites representing a range of geomorphological conditions including coastal strips whose main financial incentive is tourism and the need for sand filled beaches.

Representing Spain, the Environmental Hydraulics Institute at the University of Cantabria (IH Cantabria) were selected as they are expert in providing knowledge, evidence, methods, tools and technology relevant to the achievement of the Sustainable Development Goals (SDGs) with special emphasis on the water cycle related SDGs, following an integrated, transdisciplinary, stakeholder-oriented approach in a collaborative framework. They work extremely closely with the Ministry for the Ecological Transition and the Demographic Challenge (MITECO) and, particularly, with the Sub-Directorate for the protection of the coast (SGPC) which aims at protecting the coastal and marine environment and at guaranteeing its free and public use.

Representing the United Kingdom, The British Geological Survey were selected as they are the UK's premier provider of objective and authoritative geoscientific data, information and knowledge to help society to use its natural resources responsibly, manage environmental change and be resilient to environmental hazards. They work extremely closely with the National Network of Regional Coastal Monitoring Programmes of England, a Network comprising 6 Regional Programmes, collecting coastal monitoring data in a co-ordinated and systematic manner to serve the needs of coastal engineering and management as well as the Environment Agency and the Geospatial Commission of which they are a founding member.

Representing Ireland, the Geological Survey of Ireland is Ireland's public earth science knowledge centre and is a division of the Department of the Environment, Climate and Communications. They deal with a diverse array of topics including bedrock, groundwater, seabed mapping, natural disasters, and public health risks. They also work very closely advising the Office of Public Works (OPW), the Irish government office whose primary function is to support the implementation of government policy.

Representing the Province of Quebec, Arctus in association with the University of Quebec at Rimouski, and provides advice to the provincial government of the province of Quebec.

Representing Italy (during the CCN only), the Italian National Institute of Environmental Protection and Research acts under the vigilance and policy guidance of the Italian Ministry for the Environment and the Protection of Land and Sea (Ministero dell'Ambiente e della Tutela del Territorio e del Mare). The Institute performs scientific, technical and research functions as well as assessment, monitoring, control, communication, training and education activities.



During this CCN two new media partners have been engaged to help broaden the scope for outreach.

MediaPlanet were approached as they deliver best-in-class content marketing campaigns for more than 8,000 clients around the globe. They make branding easy for clients by taking care of the entire value chain – from concept to production and distribution, and by collaborating with top influencers and world-renowned media houses. Each year, they develop and produce 900 themed campaigns in 11 languages within our key content verticals: health, lifestyle, technology, business and cause. Through **MediaPlanet** a World Oceans Day campaign was established to promote the **Coastal Erosion from Space** “brand”.

Science Animated have a mission to communicate research effectively, beautifully and with maximum impact. Since launching, they have worked with 215 institutions to create over 280 animations for research teams in 26 countries. Their team has grown to include over 30 editors, animators, project managers, artworkers, and social media experts. ARGANS, as an SME in Earth Observation, doesn't have the skills to effectively communicate their efforts to their chosen audience, whether that's their peers, the public or potential investors. So that is where **SciAni** come in. Their team of communication experts have worked with ARGANS help define the **Coastal Erosion from Space** message and communicate it in the most effective way.

2 Summary of Deliverables

2.1 Conference and Publications

A mix of professional trade and academic events have been attended during the CCN period. Only those in which a presentation specifically alluding to the **Coastal Erosion from Space** project was presented have been included below.



Figure 3: 37th International Conference on Coastal Engineering

Advances on the use of Satellite Derived Products to Detect Coastal Changes: A Demonstration Case on the Coast of Spain was presented by Ernesto Mauricio González Roíguez, Fundación Instituto De Hiáulica Ambiental, Spain



Figure 4: GEO Blue Planet 5th Symposium

At the Intergovernmental Group on Earth Observation’s Blue Planet Symposium in Accra, Ghana the Technical Lead for the **Coastal Erosion from Space** project, Anne-Laure BECK presented on Coastal monitoring and Flooding Risk Mitigation showcasing the work achieved to a wide audience. She was also invited to deliver a component of the Coastal Workshop, working alongside Ghanaian partners, to deliver EO-derived coastal indicators to better understand and map coastline changes.



Figure 5: OCRE Final Review Conference, Lisbon Dec 22.

The OCRE Final Review took place in Lisbon 6-7 Dec and ARGANS were joined by BGS to present the mapping of the complete GB mainland coast employing the techniques delivered from the **Coastal Erosion from Space** project.



Figure 6: EGU General Assembly, Vienna

ARGANS' Anne-Laure BECK was active again educating the EGU audience on improved terrain modelling and flood mitigation as well as the benefits of employing EO techniques to monitor coastal change.

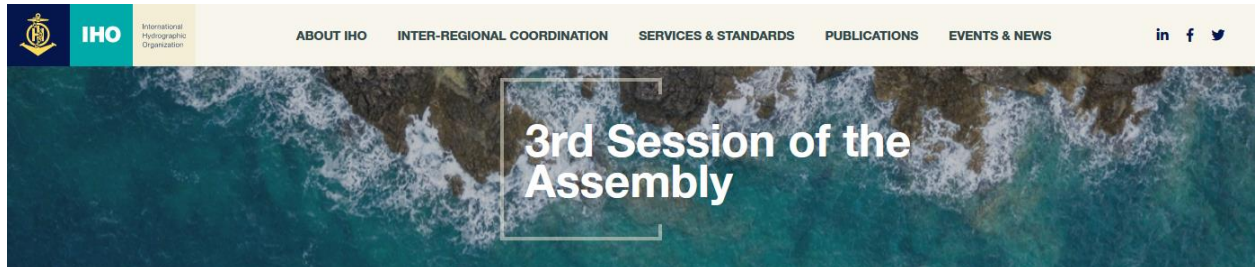


Figure 7: IHO 3rd General Assembly, Monaco.

The International Hydrographic Organisation's 3rd General Assembly provided an excellent opportunity to meet and brief with over 100 Hydrographic Offices from around the world. Many National HO's have now migrated from being purely marine navigation in focus to becoming marine geospatial or "hydrospatial" institutions with a remit that spans coastal and marine information. AS well as briefing on traditional marine topics such a satellite derived bathymetry the opportunity was take to brief on coastal change monitoring, highlighting the work conducted within the **Coastal Erosion from Space** project.



Figure 8: GEO Business 2023, London

GEO Business is an annual professional trade event where coastal engineering and construction meet geospatial provision. Every year since the **Coastal Erosion from Space** project has commenced has seen an increase in coverage of Earth Observation capabilities and this year the work based on satellite derived coastal indicators for Ghana was briefed.



Figure 9: UK Coastal Research Conference, July 2023, Plymouth

<https://youtu.be/bIUBS6NLoGA>

The University of Plymouth Coastal Processes Research Group (CPRG) in partnership with the National Network of Regional Coastal Monitoring Programmes (NNRCMP) will host the first UK Coastal Research Conference to be held in July 2023 in Plymouth.

This conference will be to showcase and celebrate the coastal research being undertaken within the UK. Principally focused on UK academics, organisations and institutions working on UK coastal science.

Central Themes

- Coastal processes in the UK – focused on process-based research of coastal systems.

- Innovation in coastal research – developments in the field of techniques, methodology, instrumentation and sensors to capture and analyse coastal data.
- Coastal data access and applications – presentation of UK coastal datasets and projects, e.g. sources beyond the National Monitoring Programme to promote collaboration and wider access.
- Applied research and FCERM (flood and coastal erosion risk management) – application of science in active coastal management projects and partnerships.

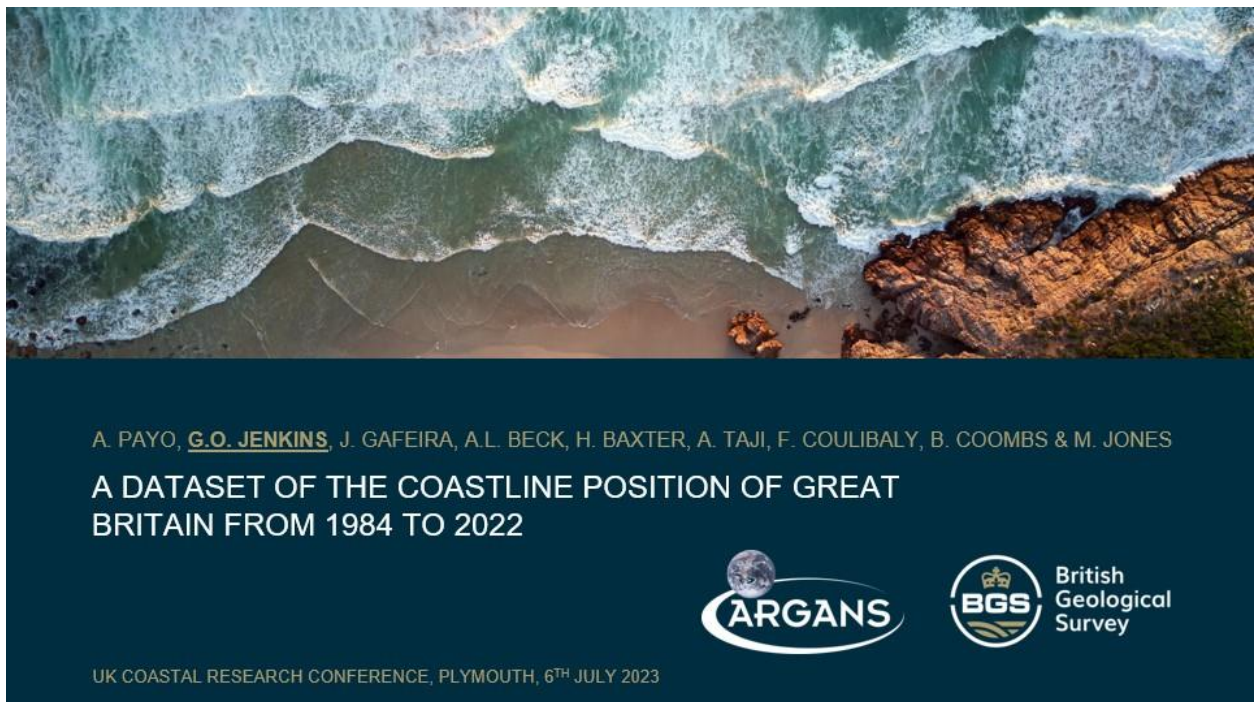


Figure 10: ARGANS/BGS presentation to UKCRC, Plymouth

ARGANS in partnership with BGS will present the GB dataset based upon the **Coastal Erosion from Space** project.

In addition, BGS have identified that Ground Engineering Magazine (v popular with coastal engineering industry) could provide an additional outreach opportunity as they intend to run a coastal edition in late November 2023. <https://www.geplus.co.uk/?s=Hemsby>

2.2 The Tutorial

One of the key deliverables for the CCN to design a “tutorial” that adequately explains the value of the Coastal Erosion from Space project outcomes and how managers of coastal defence can exploit this technology. The task also required to tutorials to be available in the languages of the consortium, ie English, French, Spanish and Italian.



Figure 11: The four language EO for Coastal Management Tutorials

Acknowledgments:

The Coastal Erosion from Space project, 4000126603/19/H-LG, was commissioned under the Science for Society slice of the 5th Earth Observation Envelope Programme (EOEP-5) of the European Space Agency.



The Headlines The consortium developed a method to optimise the number of customer ready co-registered waterlines and datum referenced shorelines seasonally covering 25 years that have been validated by the leading technical geomorphological experts within the five partners' nations. Over 4000km of coastline was mapped. These products deliver inter-pixel accuracy, use a locally adaptive threshold method to accurately determine the position of the land/sea boundary precisely and can be scaled to cover complete nations worldwide. Indeed, each partner nation intends to continue this work to provide national coverage. We have developed a land classification map that describes the coastal strip, including coastal features and their inter-annual changes which enable beach width to be determined. Boundaries have been pushed using satellite derived bathymetry techniques based on a long history of this technology to observe features of interest even in the sediment laden waters.

This project has been led by ARGANS Ltd who formed a partnership consisting of an EO based information service provider group of Earth Observations and Data experts comprising ARGANS Ltd (UK/Fr), isardSAT (Spain) and adw@isEO (Luxembourg) who delivered to an authoritative public User Group of national representatives from the British Geological Survey, the British government experts, the Cantabria in Spain on behalf of the Spanish government's *Ministerio para la Transición Ecológica y el Reto Demográfico* (MITECO), Geological Survey Ireland, the Irish Department of Environment, Climate and Communications and ARCTUS representing the Canadian academic world and the local communities of Québec. For the CCN an additional national expert from Italy was added to the consortium, namely the Italian National Institute of Environmental Protection and Research.



Figure 12: Tutorial acknowledgements

2.3 The Brochure

In addition to the tutorial described above it was also considered useful to help promote the **Coastal Erosion from Space** brand via a brochure that could be handed out at conferences and talks.



Tailored products that enable cost-efficient coastal planning.

PROTECTING YOUR COASTLINES

ARGANS

Coastal Erosion presents a pressing and increasing management problem with irreconcilable social and economic implications.

- Erosion is a natural process, amplified by climate change, that also varies due to season and human development.
- Mapping coastline change using satellite observations enables a nationwide perspective to monitor the effect of these changes over multiple timescales.

BASELINE

- Sentinel-2 only.
- Co-registration is conducted BUT imagery not provided.
- All available waterlines.
- Datum related shorelines.

PRECISION

- Sentinel-2 & LANDSAT
- BASELINE +
- Co-registered imagery.
- Annual coastal strip classification map based on year of clients choosing.

PRECISION +

- Sentinel-2 & LANDSAT
- PRECISION +
- Datum shorelines supported by auxiliary data.
- Annual coastal strip classification maps.

Project initiated by **esa**

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Figure 13: Protecting Your Coastline brochure front page.



Figure 14: brochure inside pages

2.4 The Media Approach

2.4.1 SciAni.Com

A decision was taken to work with SciAni to increase the outreach potential. Animation is the perfect tool to explain scientific capabilities to a wider audience. Eye-catching visuals engage the audience and allow even the most complicated topic to be explained. Studies have shown that there is a significant improvement on learning, recall and retention when using video resources versus text-based resources. Videos are shared 1200% more than text or image. Animation effectively promotes long-term knowledge retention, whether that is in academics or government decision makers. Online videos are twice as likely to be shared and the Pew Research Center shows 73% of US adults use YouTube. Videos are watched for professional as well as leisure purposes.

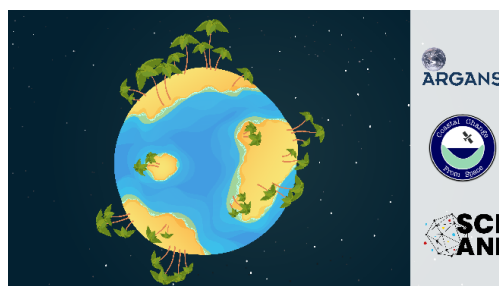


Figure 15: SciAni Animated marketing of Coastal Erosion from Space for YouTube.

2.4.2 **Media Planet** were approached to support getting the message into the New Scientist via their “World Ocean Day” campaign, and online via <https://globalcause.co.uk> on the 8th of June 2023.

<https://www.linkedin.com/feed/update/urn:li:activity:7072499752436658178>

Campaign title: World Ocean Day

Launch date: 8th June

Print partner: New Scientist

- World’s most popular weekly science and technology magazine
- Readership: 367,000
- High percentage of readers considered thought leaders by peers on issues around climate change and environment.

Digital site: globalcause.co.uk

Aim: In celebration of World Oceans Day this campaign will look at the importance of uniting global stakeholders to tackle some of the key threats facing our oceans and marine life, including pollution, overfishing and degradation. The campaign will analyse must be done to build a resilient, more sustainable aquaculture within our oceans, spotlighting the changemakers in this sector.



Figure 16: WOD article for New Scientist.

And despite there being news coverage on the BBC and every journalist engaged in the story being approached, they simply weren't interested in a scientific Earth Observation angle. It was all the human story for them.

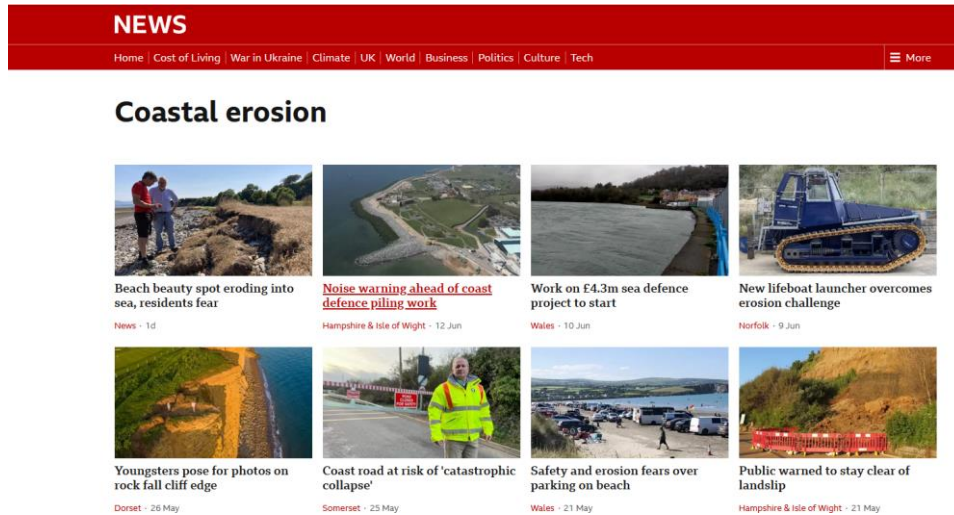


Figure 17: BBC Coastal Erosion home page

However, this didn't stop our intrepid team getting some of our own media coverage.



Figure 18: ARGANS presenting on local news channel.

3 FOLLOW ON TASKS (Generated from CE from S)

3.1 Global Development Assistance – Disaster Resilience (Ghana coast)

3.1.1 Introduction

The ESA Global Development Assistance programme is an important successor to the EO4SD programme. The essential components from an SME's perspective are the engagement opportunity to work alongside developing nations and also the International Financial Institutions. Another critical factor of this programme was the introduction of an agile development practice which enables a close bond to be developed with customers.

In this particular case a partnership of Ghana's eminent coastal erosion expertise was sought, mostly comprising the African Centre of Excellence in Coastal Resilience (ACECoR), the University of Cape Coast and the University of Ghana alongside the World Bank representative from West Africa Coastal Areas Management Plan (WACA).

At the time of drafting this Final Report the WACA team are bringing together key directors from the Ghana Ministry of Environment, Science, Technology and Innovation (MESTI) with ARGANS to discuss future opportunities for space-based evidence following the successful approval of a substantial World Bank loan to the Government. **Without the Coastal Erosion from Space project this engagement would not have been possible.**

3.1.2 Deliverables with GDA-DR

Over 200km of coastal erosion indicator products were delivered along the Ghana coast adjacent to the Volta Delta. Within this use case, various new and innovative products have been developed to help complete our understanding of coastal processes in the Keta region. The outputs of this task were all based upon the ESA Coastal Erosion from Space project outcomes. From the various time series maps produced for each year using the winter MSL shorelines, trends were observed, evolving not only along the coast ie geographically but through time as well. It could be stated that in the Keta site there has been no continuous erosion or accretion

process but change of an episodic manner. Hence, these changes are linked with various dynamics evolving with seasonal and annual cycles.

The development of new coastal products such as wave properties mapping and sediment load maps bring new light and contextual elements to help better understand why the observed coastal changes might be occurring. Sediment loads maps allow us to follow the sediment plumes, mostly from the Volta estuary, along the shore, providing a source of sand for the coast increasing coastal resilience. Waves properties, and more specifically changes in waves properties, enable us to witness the changes in erosive power leading to possible increasing erosion of the coast.

Combining time series map and the new resilience products we observed accreting section of the coast, moving north along the years to the end of Keta peninsula.

3.1.3 Time Series

Within the initial CCN, how to use shoreline to extract coastal dynamic was a central question. Different approaches were tested and the time series approach implemented takes two dates (a starting date and an ending date) to extract how the coast changed in that time range. The time series process computes the area between two lines based on the satellite derived shorelines and creates a vector layer that represent a quantitative change for the chosen time period.

The selection of the shoreline relies on a first visual assessment of the available shorelines for the period of interest. MSL shorelines have proved to be the most relevant ones to illustrate coastal change as HAT and LAT are extreme situations with specific morphologies. Also, as shorelines are derived from waterlines that might represent different coastal morphologies based on the water level, it is recommended that combined shorelines very close in time relatively to the range of the time series are selected to smooth coastal morphology variation. At the end of this first step there are two reference lines (start and end) that are either shorelines or an average line of multiple shorelines. For each line a one-side buffer (on the seaside) is created that is then clipped to keep just the polygons between the lines. Polygons derived from the starting line represent the accretion and the one for the ending line the erosion.

This approach designed within this project was then used to demonstrate changes that are observable along the Ghanaian coast.

Most coastal zone management and intervention policies heavily rely on the valuable information provided by shoreline change analysis. By using the processor to obtain datum-based shorelines, a time series analysis can be performed to assess the extent of the erosion problem in the Keta area and its surrounding coastal zone. Thanks to this it becomes possible to monitor and analyse erosion patterns, changes in coastline dynamics, and the impact of different factors such as sediment sources or sediment flow.

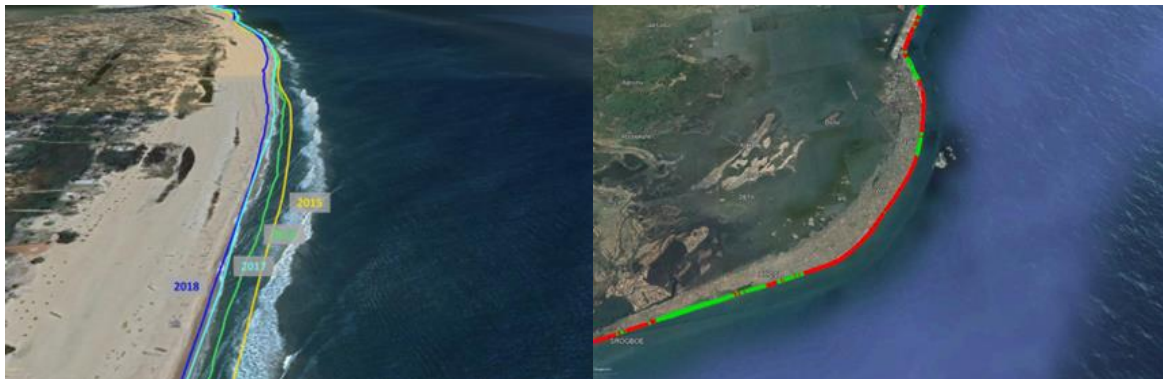


Figure 19: Left: evolution of the shorelines in the study area in different moments. Right: identification of erosion and accretion zones after calculation of changes across time series.

To visualise the general trend during the temporal frame of our analysis, a first general study compared the MSL winter shorelines of 2015 and 2021. The time series map obtained (see Figure 5) shows that, despite some accreting area, between 2015 and 2021, most of the coast around Keta was eroding.

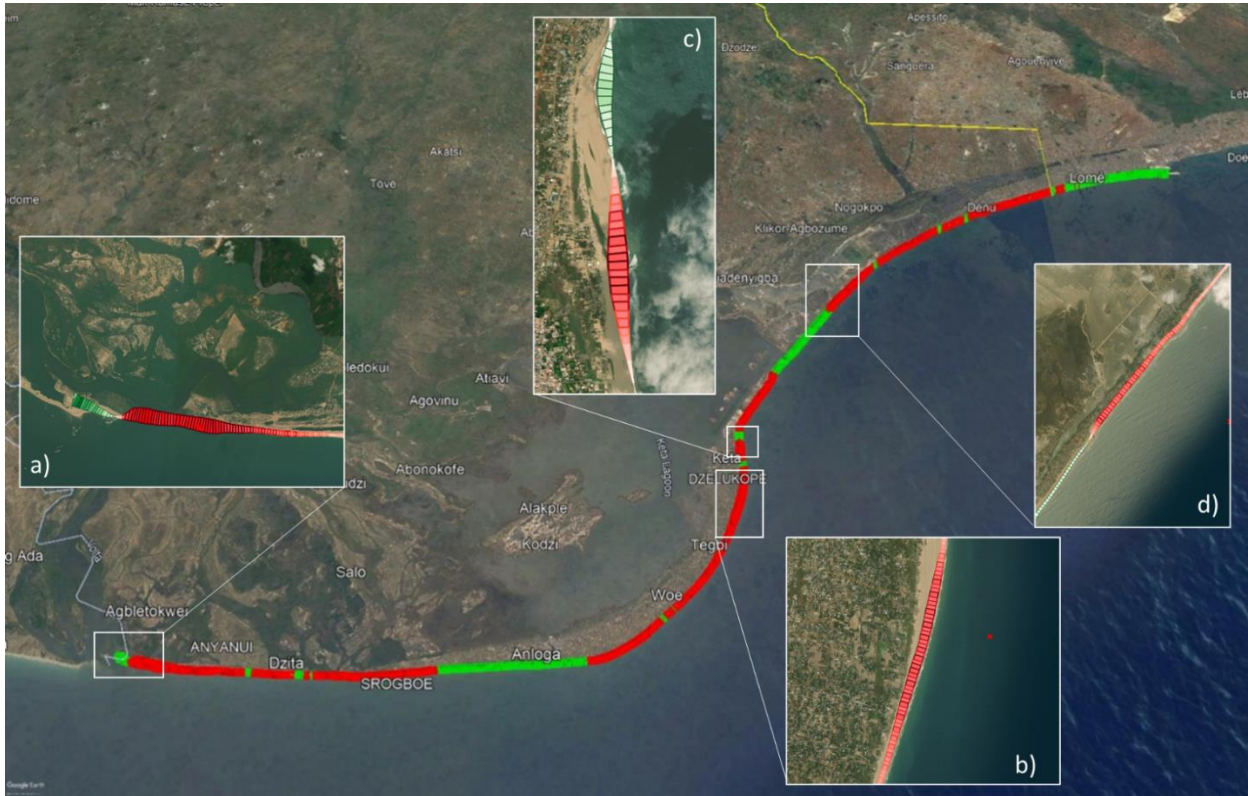


Figure 20: 2015 - 2021 MSL shoreline time series for Keta region

3.2 Open Cloud Research Environment support to mainland Great Britain shoreline project (OCRE-GB)



Figure 21: OCRE-GB Project front page



The project goal was to create a database of coastline position for the whole length of Great Britain (GB) coastlines over the period between 1984 to 2022 (38 years). The coastal length covered was **15,400 Km**.

The British Geological Survey (BGS) Coasts and Estuaries team use a combination of methods that include the use of innovative 4D simulation models and cost-effective monitoring approaches (i.e. from space and using non-intrusive survey methods) to quantitatively assess the effects of different adaptation options against coastal flooding and coastal erosion with an emphasis in the transition from traditional grey engineering (such as hold the line with hard defences) to more green engineering (a combination of nature based solutions and giving space to coastal processes).

Satellite-borne Earth Observation (EO) based on the ESA Coastal Erosion from Space project is now providing repeated monitoring of the coastline at large scale, high temporal and spatial resolution as well as low cost. It was therefore possible to assess not only the status of the coastline before and after a storm event and before and after each spring tide but also the historical trend since satellite coverage commenced back in 1984.

Quote by Dr Andres Payo, head of Coast & Estuaries hazards at British Geological Survey:

"This project is very relevant not only for BGS's Coast and Estuaries programme but for all other institutions engaged in informing coastal management decisions in the UK and internationally who are facing today the challenge of managing an increasing risk of coastal flooding and erosion which is likely to increase due to the anticipated Sea Level rise projections in the incoming years."

The key impact was enabling the translation of EO data into useful and public information to a broad range of coastal stakeholders. Information about coastal change should be made broadly available to the public. Initiatives like the European Space Agency funded Sentinel 1 and 2 missions that make the data publicly available combined with the OCRE program was a great enabler for the public and coastal stakeholders to access coastal change information.

The value of the OCRE EO Service funds was to bridge the gap between EO data and information by providing reliable evidence of coastal change for the whole Great Britain.

This project was presented to the OCRE Final Review further disseminating the value of the Coastal Erosion from Space project.



Figure 22: Mainland GB full coastline coverage

[Assessment of coastline change over the last 38 years using satellite EO along Great Britain coast | OCRE \(ocre-project.eu\)](https://ocre-project.eu)

3.3 UK tasks derived from or assoicated with Coastal Erosion from Space

3.3.1 ODSAS

To perform shoreline, change analysis the Open Digital Shoreline Analysis System (ODSAS) software tool (Gómez-Pazo, Payo et al. 2022) <https://doi.org/10.3390/jmse10010026> has been designed by BGS one of the consortium partners. ODSAS is a Transect-form Baseline approach that uses SAGA GIS and R, (R Core Team 2020) which are both free open-source software programs. ([ODSAS GitHub](#)).

ODSAS calculates for each transect the standard metrics of coastline change and rate of change similar to the metrics produced using Digital Shoreline Analysis System (DSAS) (Theiler, 2009). The outputs of the analysis are a shapefile (polyline format), that have the statistical parameters associated with each transect, and a tabular report with the markers of central tendency for the estimated rates to understand the analysed sector's behaviour globally. The results can then be queried and visualized at the at a transect-by-transect individual level or aggregated level (i.e., metrics for all transects combined). In conjunction with weighted linear regression rate, standard error of the estimate (WSE), standard error of slope with user selected confidence interval (WCI), and R-squared value (WR2) are obtained (Thieler et al, 2009). The ODSAS software tool has been used by Paz-Delgado et al. (2022) (<https://doi.org/10.3390/jmse10050561>) to quantify shoreline change from both optical and SAR imagery.

3.3.2 DEFRA Coastal monitoring and historical change. Adaptable methodology to determine coastal change in England and Wales

The UK's DEFRA have awarded a project on coastal monitoring and historical coastal change. This project's aim is to review and collate evidence and create a methodological framework to document and visualise historical coastal change along the English and Welsh coastlines. As part of the recommendations, which are currently under review, the changes in waterlines derived from Earth Observation satellite data which have been used to identify the mean sea level using data from 38 years of available satellite coverage, enabled due to the development work derived using ESA funded project Coastal Erosion from Space are being proposed. The study assesses five uses cases although it is made clear these are not discrete and have much overlap and they are not an exhaustive list. The use cases are i) Shoreline Management including scheme design, ii) Conservation Management focussing initially on designated sites but with the potential to be extended to habitats, iii) Local Planning linking land use change to shoreline change, iv) Coastal Communities and their need to understand change, and finally v) aggregation to a national scale to support National Policy development. Possible extension includes information on the erosion and flooding hazard zones, information about the coastal defences (type, standard of protection); habitat maps; links to the regional coastal monitoring data (e.g., National Network of Regional Coastal Monitoring Programmes). Creation of short-term historical database from publicly available satellite data has been made possible due to the ESA operated Sentinel and

USGS/NASA operated Landsat Missions. Two satellite derived lines has been obtained for the study sites; the instantaneous Water Line representing the water and land interface and then converted to a datum Mean Sea Level shoreline (MSL-SL) using best LiDAR and tidal level available. The raw data used are the publicly available satellite Multi Spectral Imagery from three different missions starting in 1984 with the Landsat-5 mission (1984 to 2013), Landsat-8 mission (starting 2013 and active) and Sentinel-2A & 2B missions (starting 2015 and 2017 and active). The WL and MSL-SL has been produced for the whole Great Britain main-land by ARGANS Ltd. in collaboration with the British Geological Survey and funded by DG Connect via the Open Cloud Research Environment Programme. The methods used to create the satellite derived products represent the state of the art thanks to the Coastal Erosion from Space project funded by the European Space Agency (ESA), led by ARGANS Ltd in collaboration with an international consortium. The details of the methodology used for the pre-processing, georectification, extraction and production are all available via the project website <https://coastalerosion.argans.co.uk/>.

This brief has been created by ARGANS Ltd as part of ESA CCN2 final report. Therefore, any views or opinions represented in this section are personal and belong solely to the report creator and do not represent those of people, institutions or organizations that the creator may or may not be associated with in professional or personal capacity, unless explicitly stated.

<https://youtu.be/ABnTPqSbryo>

3.4 UKSA Enabling Technology – a global capability to support developing nations.



One of the key lessons identified during the ESA Coastal Erosion from Space project was the need to translate the instantaneous Waterline into a comparable line at a specific state of tide. Datum based shorelines were developed and these rely on auxiliary data on beach gradient and coastal tidal heights. Further experience of working within the ESA Global Development Assistance -



Disaster Resilience project identified that many developing nations have no or very sparse geospatial information archives or current data gathering capabilities.

This conundrum has formed the basis of an application for a grant from the UKSA to continue the work developed under the ESA Coastal Erosion from Space project.

The question posed is “How can Earth Observation from satellites shape more robust coastal management plans around the world?”

The Global Shoreline consortium comprising ARGANS working with isardSAT, and the University of Southampton will develop a globally applicable shoreline processor that is suitable for use in developing nations that do not possess historical beach gradient or tidal data. Current experience working in Ghana with the World Bank West Africa Coastal Areas (WACA) Programme has identified a huge gap in data and International Financial Institutions such as the World Bank wish their loans for coastal resilience to be spent backed by scientific evidence of the problem to be overcome. Using innovative technologies to exploit both Multispectral Imagery and SAR imagery coupled with altimeter and gauge based tidal models a new approach to mapping coastal indicators can be achieved which will enable sound development and sea defence investments to be made.

Through this funding ARGANS will be able to develop an innovative and novel application that will be scalable globally and particularly applicable to nations with limited access to geospatial information. This will place ARGANS in a strong position to work with the International Financial Institutions, it will deliver the kernel to deliver a global coastline which has been introduced by ESA at their ITT day March 2023. In turn this will allow for ARGANS to compete on a global scale and showcase the ability of British research and application to an ever-growing topic and market. ARGANS already has a great reputation within ESA for Coastal Monitoring and this grant will expand their position globally and showcase their skills and capabilities. With an increasing realization of how climate change will affect coastal communities and small island states it has become important for investment decision of mitigation and adaptation plans to be based around evidence.

4 Overall Summary

4.1 Coverage during the project

And finally, some statistics for the project, which selected **21 sites** to study with a range of different and often very complex geomorphologies, in order to **test the limits** of the technologies.

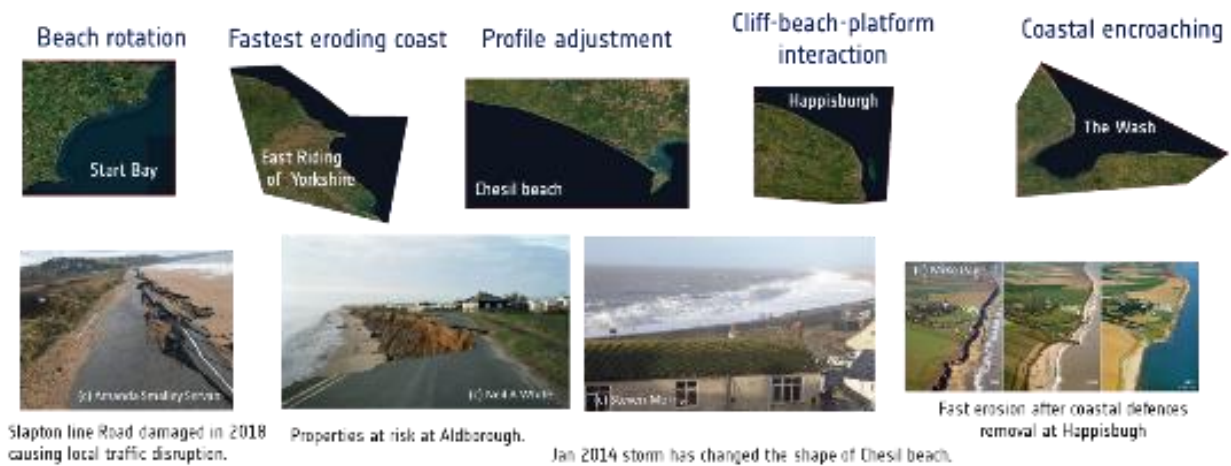


Figure 23: coastline types observed.

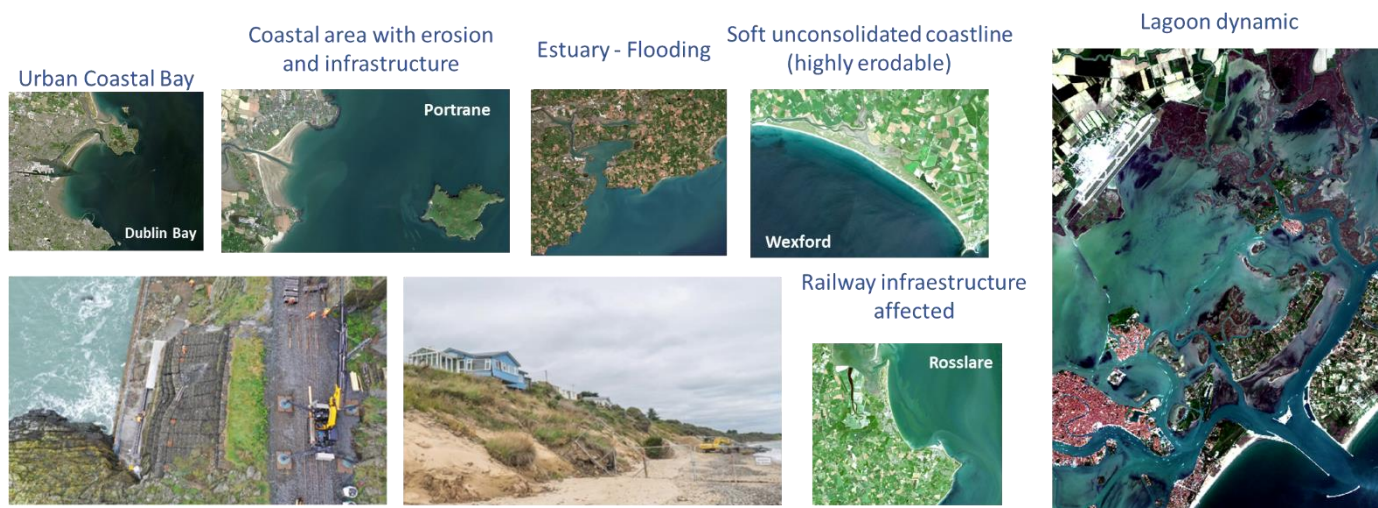


Figure 24: Structural and morphological description of the study sites

With an **expansive product scope**, producing over 30,000 products which includes just over 5000 waterlines, **analysing over 7300 km** of coast. Spanning over **25 years of satellite imagery**.

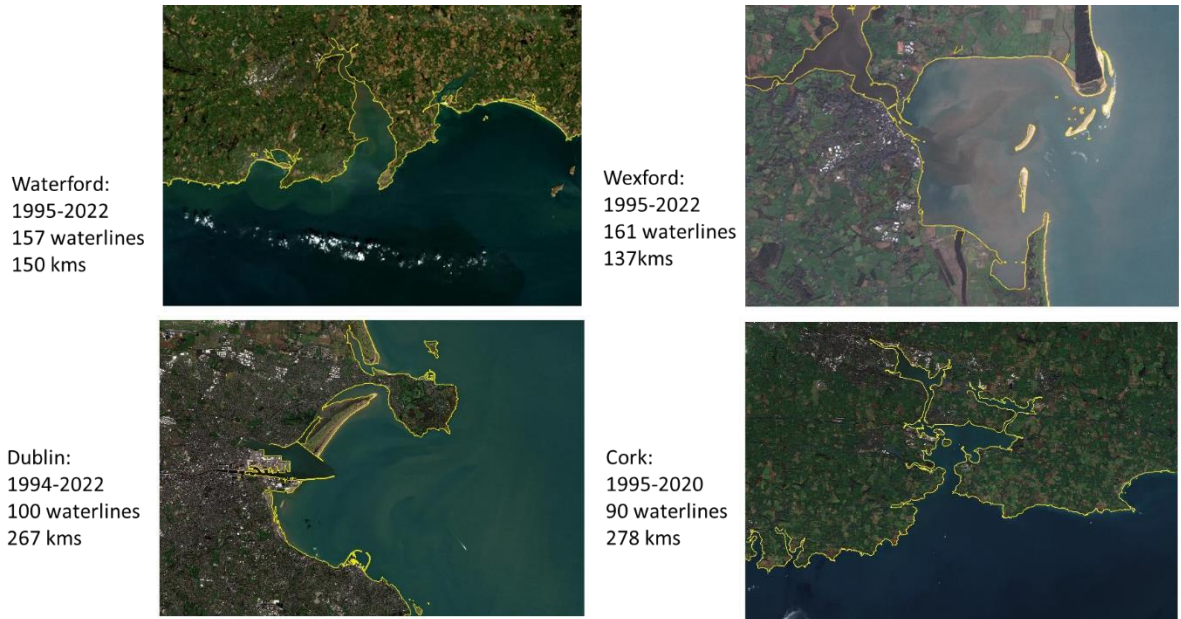


Figure 25: Irish demonstration sites

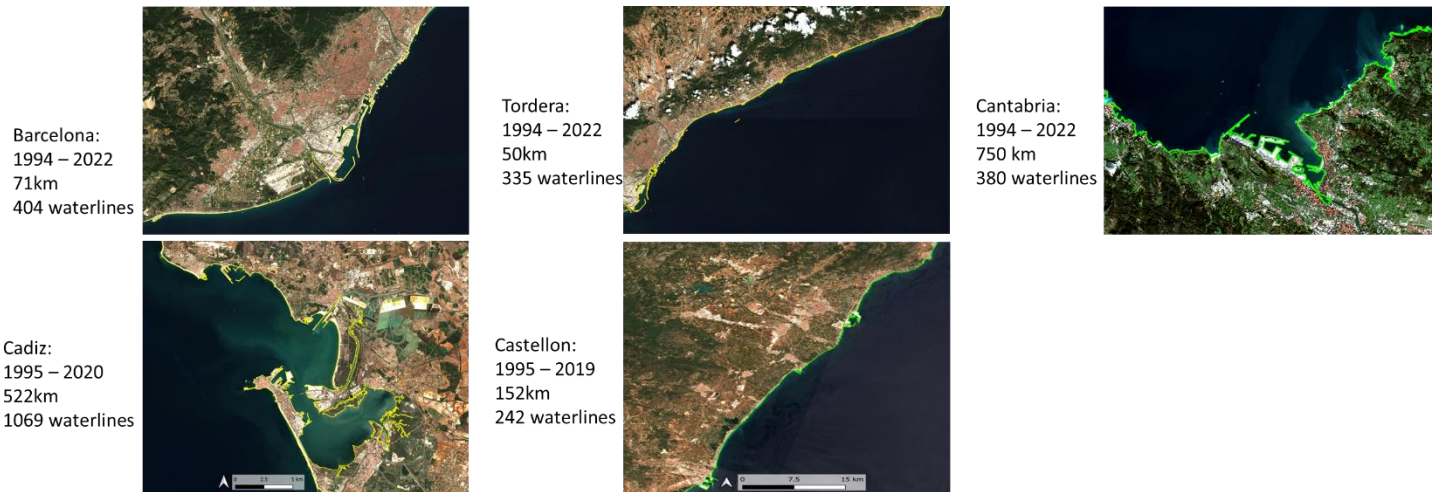


Figure 26: Spanish demonstration sites

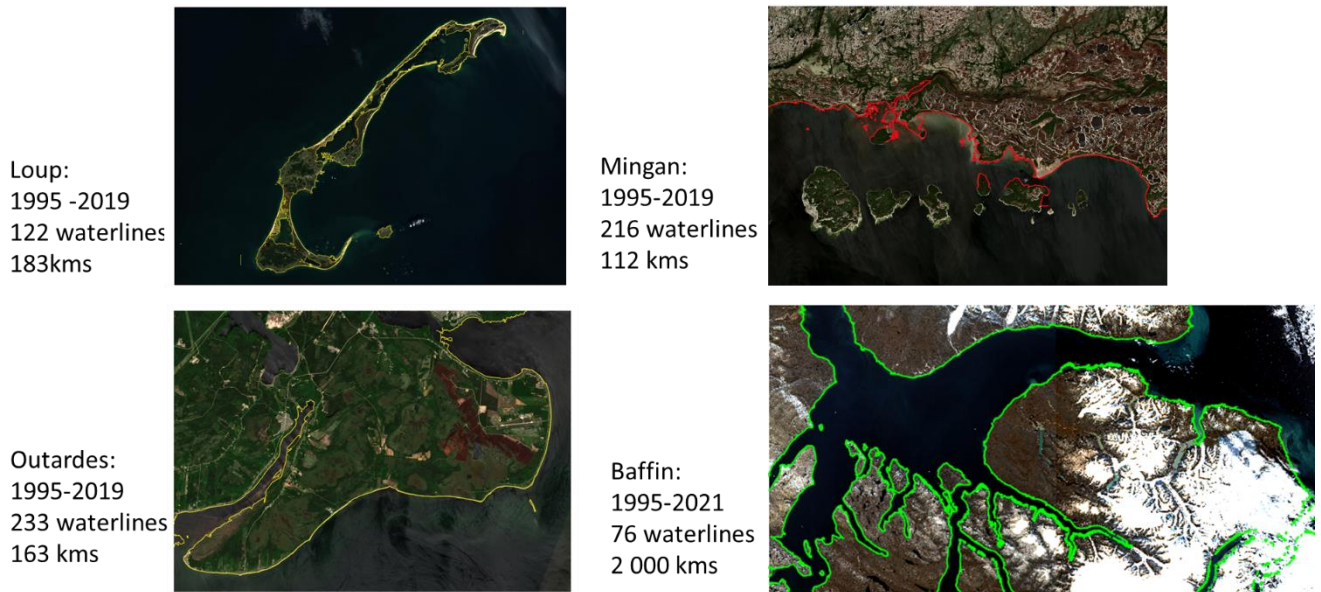


Figure 27: Quebec demonstration sites

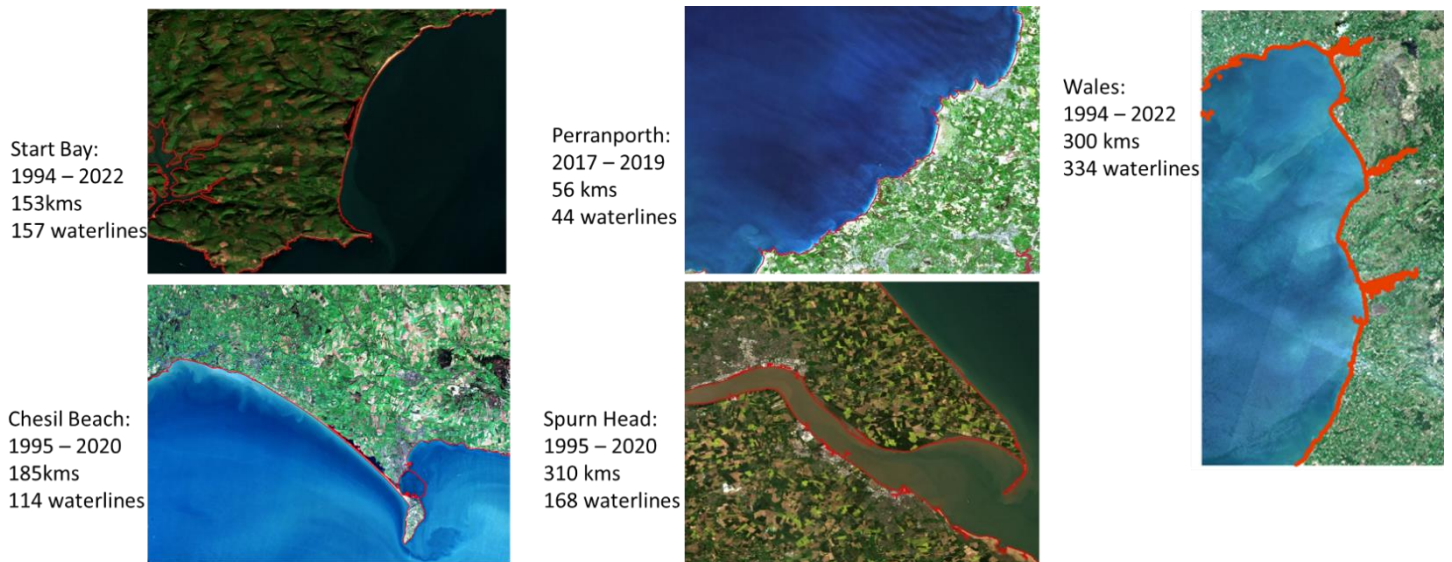
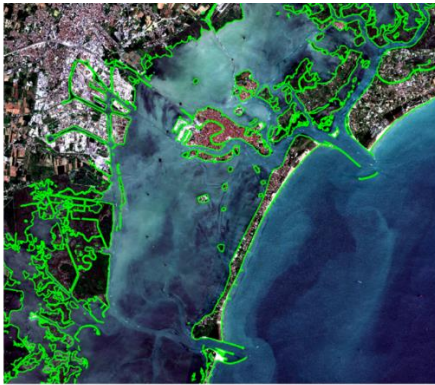
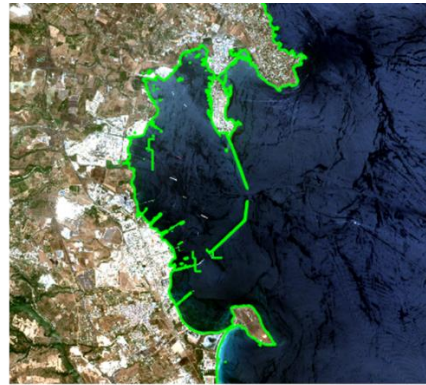


Figure 28: GB demonstration sites



Venice:
1994 – 2022
1 150 kms
714 waterlines

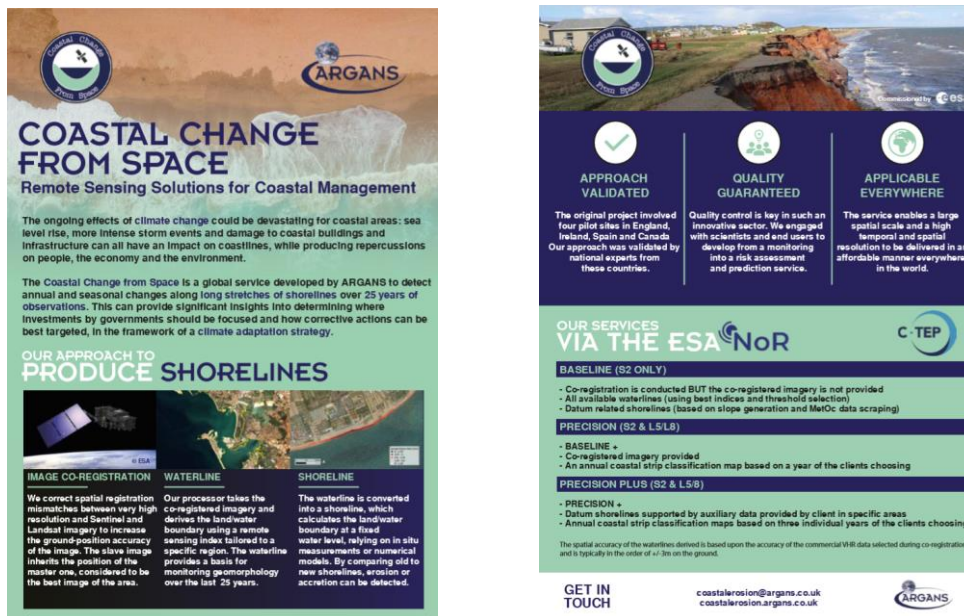


Catane:
1994 – 2022
395 kms
396 waterlines

Figure 29: Italian demonstration sites

4.2 Platform opportunities

As part of the strategy to market the outputs from the Coastal Erosion from Space project an opportunity was presented to place the products within the Open Cloud Research Environment catalogue. <https://www.ocre-project.eu/eo-catalogue>. This project has now completed and no further funded is expected, however DG Connect who funded the concept programme have intimated that the European Open Science Cloud programme may become a successor. To support the OCRE Catalogue a marketing pamphlet was created.



COASTAL CHANGE FROM SPACE
Remote Sensing Solutions for Coastal Management

The ongoing effects of climate change could be devastating for coastal areas: sea level rise, more intense storm events and damage to coastal buildings and infrastructure can all have an impact on coastlines, while producing repercussions on people, the economy and the environment.

The Coastal Change from Space is a global service developed by ARGANS to detect annual and seasonal changes along long stretches of shorelines over 25 years of observations. This can provide significant insights into determining where investments by governments should be focused and how corrective actions can be best targeted, in the framework of a climate adaptation strategy.

OUR APPROACH TO PRODUCE SHORELINES

IMAGE CO-REGISTRATION
We correct spatial registration mismatches between very high resolution and Sentinel and Landsat imagery to increase the ground-position accuracy of the image. The slave image inherits the position of the master one, considered to be the best image of the area.

WATERLINE
Our processor takes the co-registered imagery and derives the land/water boundary using a remote sensing index tailored to a specific region. The waterline provides a basis for monitoring geomorphology over the last 25 years.

SHORELINE
The waterline is converted into a shoreline, which calculates the land/water boundary at a fixed water level, relying on in situ measurements or numerical models. By comparing old to new shorelines, erosion or accretion can be detected.

APPROACH VALIDATED
The original project involved four pilot sites in England, Ireland, Spain and Canada. Our approach was validated by national experts from these countries.

QUALITY GUARANTEED
Quality control is key in such an innovative sector. We engaged with scientists and end users to develop from a monitoring into a risk assessment and prediction service.

APPLICABLE EVERYWHERE
The service enables a large spatial scale and a high temporal and spatial resolution to be delivered in an affordable manner everywhere in the world.

OUR SERVICES VIA THE ESA NoR

BASELINE (S2 ONLY)

- Co-registration is conducted BUT the co-registered imagery is not provided
- All available waterlines (using best indices and threshold selection)
- Datum related shorelines (based on slope generation and MTDc data scraping)

PRECISION (S2 & L5/L8)

- BASELINE +
- Co-registered imagery provided
- An annual coastal strip classification map based on a year of the clients choosing

PRECISION PLUS (S2 & L5/B)

- PRECISION +
- Datum shorelines supported by auxiliary data provided by client in specific areas
- Annual coastal strip classification maps based on three individual years of the clients choosing

The spatial accuracy of the waterlines derived is based upon the accuracy of the commercial VHR data selected during co-registration and is typically in the order of +/- 3m on the ground.

GET IN TOUCH
coastalerosion@argans.co.uk
coastalerosion.argans.co.uk

Figure 30: OCRE Catalogue for Coastal Erosion Services

5 Conclusion & Recommendations

5.1 The key points

The current system is ready to produce “commercial ready” products, albeit in a semi-autonomous fashion and this capability is now available via the OCRE EO Catalogue. <https://www.ocre-project.eu/eo-catalogue>. The UK was awarded an OCRE voucher to continue to map the complete GB coastline which has been delivered. All the other partner nations, (Ireland, Italy, Spain and Canada) applied to OCRE for their nations but were unsuccessful. Within the ESA Global Development Assistance programme under the Disaster Resilience project this capability is also being applied to the coastline of Ghana.

In short coastal management based on products derived from Earth Observation has come of age and a “standard” has been established by the Coastal Change Consortium led by ARGANS Ltd which has only been possible due to the foresight and support of ESA and the collaboration of expert partners who represent their nations in the field of geology/hydraulics.

5.2 Lessons Identified/Recommendations.

The key points that have been identified during this short CCN are:

- Access to the ESA Communications System could be considered for future flagship projects that would like to better expose the successes delivered. The ability to provide the source material and then to be able to exploit the remarkable capabilities and network that ESA possess would have been a great success.
- The GDA-DR project has enabled the opportunity to work with a programme manager within the World Bank. This would be virtually impossible for an SME Earth Observation company on its own and is considered a great opportunity. Links to the International Financial Institutions via the GDA should be encouraged. Perhaps consideration could be given to an ESA funded IFI workshop to showcase key projects such as the Coastal Erosion from Space project that have relevance to Development or Resilience.
- The **Coastal Erosion from Space** project was very successful in part due to the funding of a local expert user group that also provided validation. The service provided within the Coastal Change Consortium was first class and the Coastal Erosion from Space project is

an exemplar. The experiences, however, building the Ghana Resilience Group as a volunteer support team was constrained by what effort it could provide. Consideration of the former approach would be a strong recommendation and precedence to establish.

- OCRE - the initial plan had been to split the €8.5M assigned equally between EO services and Cloud Services. 30 cloud projects were awarded (limit was €500k each) and only 12 EO projects (which had a €1-200k limit). It was stated at the Final Review by the Prime that cloud services could be commoditized, and a framework contract agreed with providers, and this wasn't the case for EO services. OCRE was described as a test bed to support the European Open Science Cloud (EOSC) and that had plans to deliver what they called a "horizontal services" layer, ie EO services. These horizontal services might be an ideal location for coastal erosion services to be advertised to foreign governments and any future ESA EOSC liaison might wish to ensure EO services are better understood and supported.



End of Document