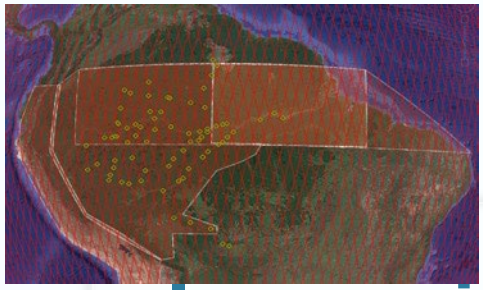

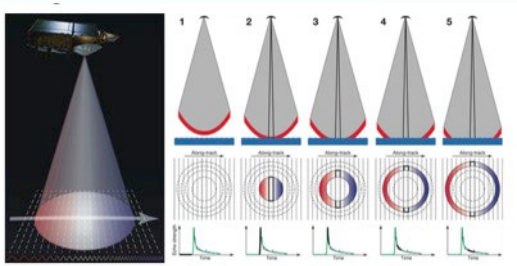

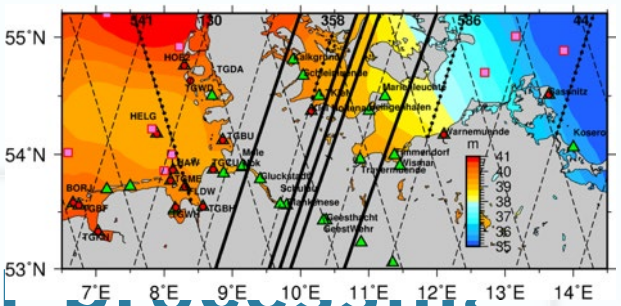

Improving SAR Altimeter processing over the coastal zone and inland waters - the ESA HYDROCOASTAL project.

D. Cotton, Albert Garcia-Mondejar, Stephanie Urien, Ester Vendrell, Christine Gommenginger, Ole Andersen, Karina Nielsen, Heidi Ranndal, Luciana Fenoglio-Marc, Michele Scagliola, Mathilde Cancet, Marcello Passaro, Denise Dettmering, Pierre Fabry, Nicholas Bercher, Angelica Tarpanelli, Stefano Vignudelli, Francesco de Biasio, Peter Bauer-Gottwein, Joana Fernandes, Cornelis Slobbe, Marc Naeije, Jesus Gomez-Enri, Peter Thorne, Elena Zakharova, Andy Shaw, Marco Restano, Jérôme Benveniste

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Introduction

- The junction between the coastal zone and inland waters is a boundary between
  - Different science domains (hydrology and oceanography),
  - Different satellite measurement regimes.
  - Region of high variability in small spatial and temporal scales.
- HYDROCOASTAL aims to enhance our understanding of
  - interactions at this boundary,
  - the small-scale processes that govern these interactions,
  - to improve characterisation of variation at different time scales of inland water storage,
  - exchanges with the ocean and the impact on regional sea-level changes.

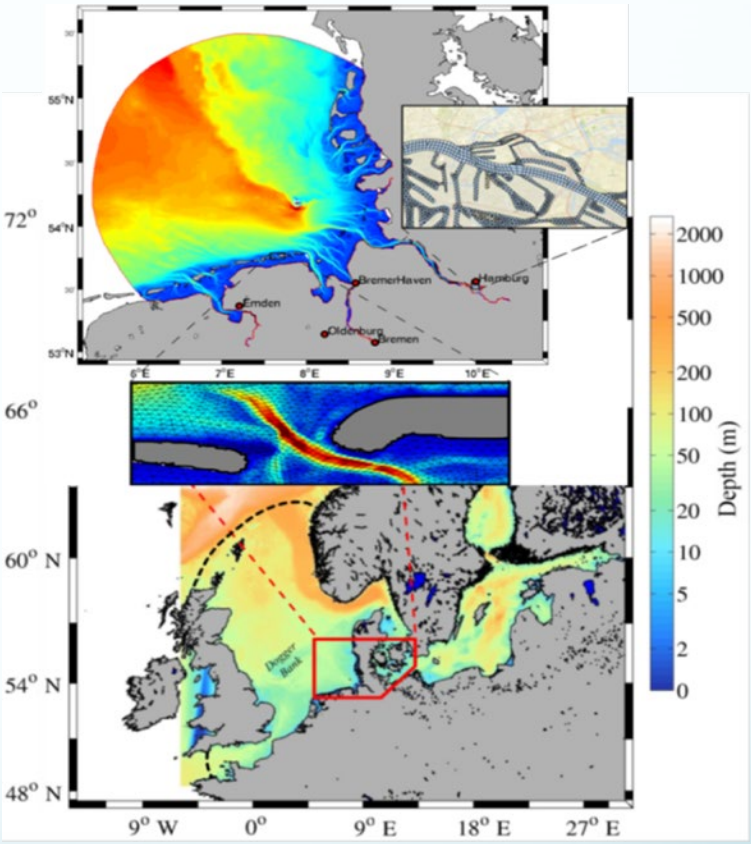


Image courtesy of U Bonn: German Coast of the North Sea and the Elbe Estuary

The HYDROCOASTAL Project

- HYDROCOASTAL is funded under the ESA Science for Society Programme Element.
- Aim is to maximise 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.
- New SAR and SARin processing algorithms for the coastal zone and inland waters will be developed and tested, and a processing scheme will be implemented to generate global coastal zone and river discharge data sets.
- Case studies will assess these products in terms of their scientific impacts
- 15 partners:
  - SatOC (prime), isardSAT, National Oceanography Centre (UK), DTU Space, the University of Bonn, Aresys, Noveltis, DTU Environment, the Technical University of Munich, the University of Cadiz, Along-Track (with AltiHydro Lab), Consiglio Nazionale (ISP, IRPI and IBF), National University of Ireland – Maynooth, and the University of Porto and the Technical University of Delft

HYDROCOASTAL Overview

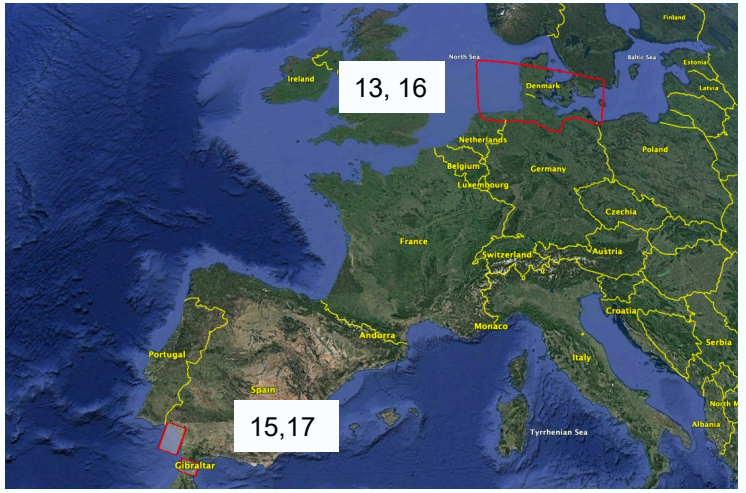
1. **Scientific Review and Requirements Consolidation (completed)**
   - Review the current state of the art in SAR and SARin altimeter data processing as applied to the coastal zone and to inland waters.
2. **Implementation and Validation (July 2020 – May 2022)**
   - Implement new SAR, SARin altimeter processing algorithms to generate 2-year test data set.
   - Evaluate performance of the candidate algorithms.
   - Selected algorithms used to generate “global” coastal zone and inland water final products
3. **Impact Assessment (June – December 2022)**
   - The impact of global products assessed through a series of case studies
4. **Outreach and Road Map (April 2023)**
   - Recommendations for further R&D and implementation in current and future SAR altimeter missions

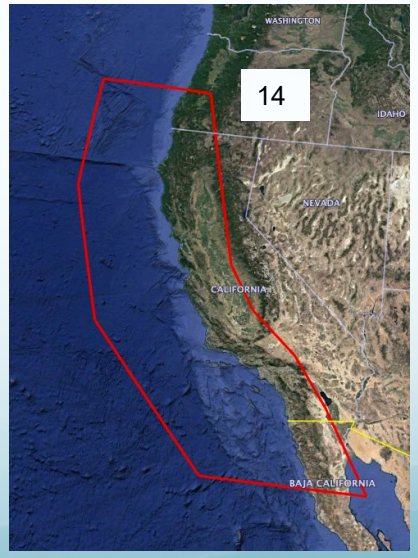
1st HYDROCOASTAL Test Data Set

- 18 Regions of Interest to cover a wide range of inland water and coastal zone characteristics.
- 2 years data 2018-2019, 3 years for regions with river discharge estimates
- Inputs
  - CryoSat FBR baseline D SAR and SARin mode data.
  - Sentinel 3A and 3B SIRAL L1A data
- Enhanced Wet and Dry Troposphere Corrections (U Porto)
- Documented descriptions of processing schemes and products at *www.satoc.eu/projects/hydrocoastal*
- Available on request by email to *info@satoc.eu*

1st HYDROCOASTAL Test Data Set

Region	Name	Country	Target Type
TDS1-01	River Rhine	Germany	River
TDS1-02	River Danube	Hungary, Serbia, Romania, Bulgaria	River
TDS1-03	River Amazon – Solimoes	Brazil	River
TDS1-04	River Ob	Russia	River
TDS1-05	River Po	Italy	River
TDS1-06	River Yangtze	China	River, estuary
TDS1-07	River Mississippi	USA	River
TDS1-08	Nonacho Lake	Canada	Lake
TDS1-09	River Amur/Songhua	China, Mongolia, Russia	River, wetland, estuary
TDS1-10	Ionian / Aegean	Greece	Coastal /SARin
TDS1-11	Reindeer Lake,	Canada	Lake
TDS1-12	Zambezi River	Zambia, Mozambique	River
TDS1-13	German Bight, Baltic Coast	Germany	Coastal
TDS1-14	California Coast	USA	Coastal
TDS1-15	Huelva and Bonanza	Spain	Coastal, Estuary
TDS1-16	Elbe Estuary	Germany	Estuary
TDS1-17	Tarifa	Spain	Coastal
TDS1-18	Caspian Sea	Russia	Inland Sea

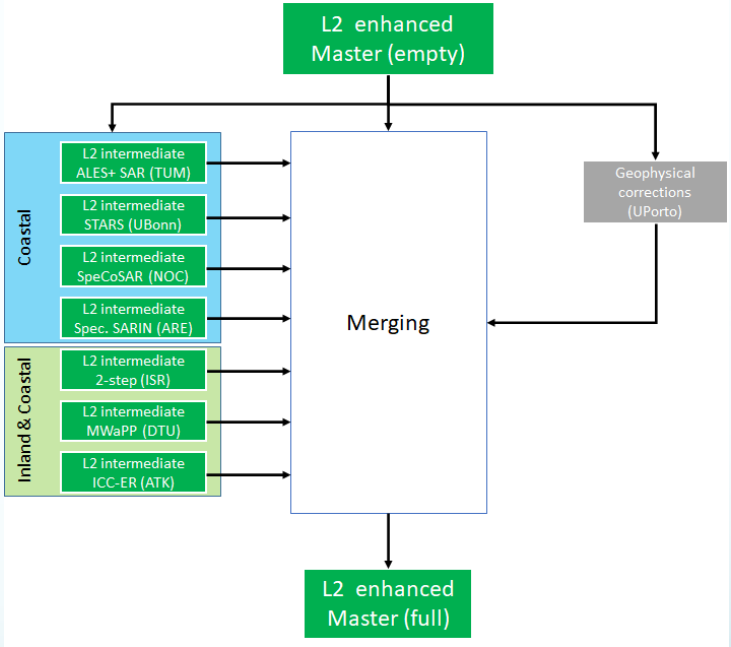




Candidate L2 algorithms

Six candidate L2 processing algorithms have been implemented. Their performance is being evaluated, and algorithms will be selected to generate global coastal zone and inland water products in the second year of the project.

1. Two Step Analytical Processor – coastal and inland: isardSAT
2. Specialised SARin – coastal: Aresys*
3. MWaPP – Multiple Waveform Persistent Peak – inland: DTU Space
4. ICC-ER (Isolate, Cleanse, Classify · Empirical Retracker – inland: ATK
5. Statistical Re-tracker STARS type – coastal: U Bonn
6. ALES+ for SAR · coastal: TU Munich*



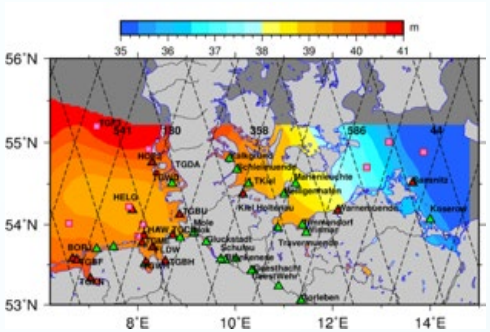
HYDROCOASTAL L2 product merging. The L2 enhanced Master will include output from all L2 processors. (credit: isardSAT)

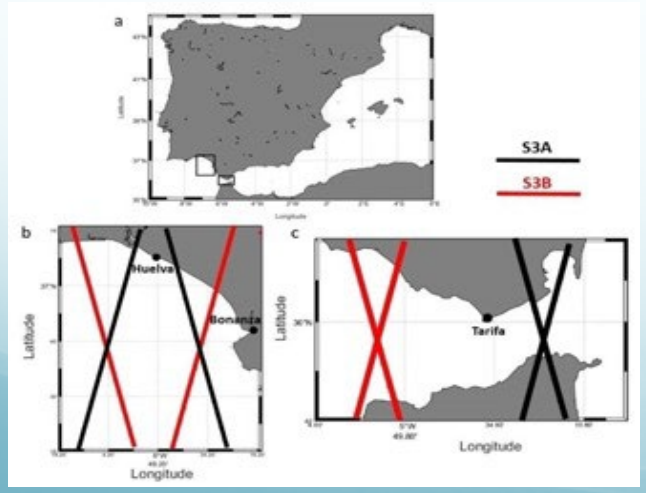
* Available via ESA's altimetry virtual lab · POSTER 24/05 1800

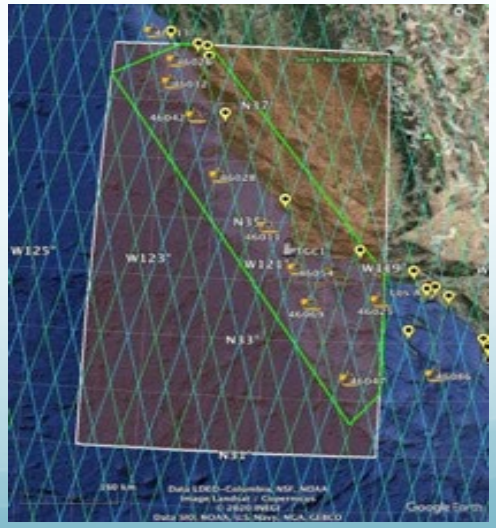
First Test Data Set Evaluation

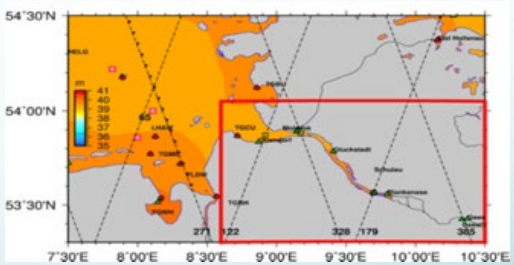
The performance of the different processors will be evaluated through detailed studies and with a set of agreed metrics, as described in the *Product Validation Plan*:

- **Coastal Zone -L2**
  - German Bight /Baltic Sea (U Bonn) POSTER 24/05 17:41
  - California Coast / Harvest (NOC)
  - Southern Spain (U Cadiz)
  - Land Proximity to Coast / Angle of Approach (SKYMAT)









Additional Studies

- U Porto – Generation and validation of enhanced Wet and Dry Troposphere corrections for Cryosat-2 and Sentinel 3A/3B for coasts and inland waters.
  - State of the art computation techniques, models, observations
  - Correction of errors in current products, enhanced handling of variations with altitude
- NOVELTIS - Assessment of tidal models in coastal regions (POSTER 24/05 17:40)
  - Where available, recent regional models provide most accurate results
  - Globally FES2014b performs best, but different global models provide better results in different regions.
- U Bonn - Vertical motion of wave particles in SAR altimeter processing
  - Including the effect of vertical motion of wave particles in SAR altimeter processing and to assess the impact of this on accuracy and precision.
- isardSAT – Processing Sentinel 6 data with isardSAT CORS coastal re-tracker, and Fully Focussed SAR processing
  - See later presentation for CORS processor

HYDROCOASTAL Global Product

- From the evaluation of the first test data set, algorithms will be selected to generate a ‘‘global’’ coastal and river data set.
- The global data set will comprise:
  - Global L2 data sets for coastal zone and inland water (SAR and SARin)
  - Global L3 data sets (time series) for selected ‘‘large to medium’’ rivers
  - Global L4 data sets (river discharge) for selected ‘‘large to medium’’ rivers
  - Experimental data set for ‘‘small rivers and tributaries’’.
- The final specifications of the global data set, including spatial and temporal coverage, will be agreed between ESA and the project team at the mid-term review.
- This product will be made freely available.
- We expect this product to be available in Autumn 2022

Please contact us if you would be interested in accessing this data set, and would like to recommend regions to be covered

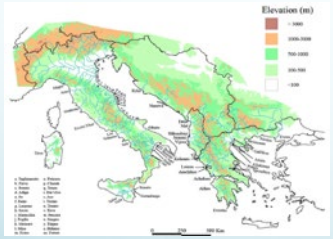
Impact Assessment

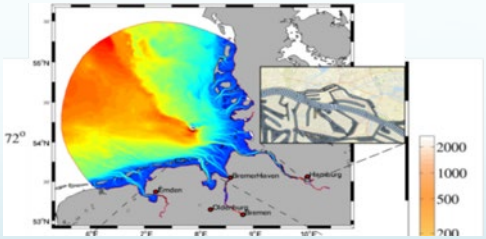
A series of impact assessment studies will be carried out, to test and demonstrate the potential impact and benefits of the global dataset.

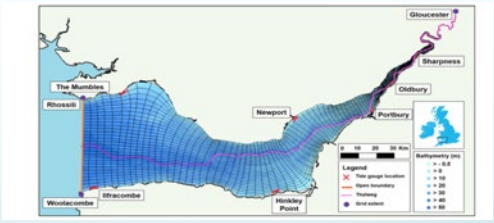
Processing Case Studies
- Fully Focused SAR (Aresys, isardSAT)
- Attitude Errors (Aresys)
- Along and Across track slope (Aresys)
- Open Loop Tracking Study (NOVELTIS)
- Phase Unwrapping / Across Track Slope (DTU Space)

Coastal / Inland
- Severn Estuary (NOC)
- Baltic, German Bight, Elbe Estuary (U Bonn)
- Venice Lagoon (CNR) - POSTER
- Thailand Coast (TU Delft)
- Ebro River and Delta (isardSAT)
- Wadden Sea (TU Delft)

Inland
- Operational Hydrological Forecasting (DTU Env)
- Lake Size, riverbank configuration (NUIM)
- Discharge Validation (CNR)
- Global Water Level Climatology (AHL, ATK)







Groups from outside the project team are welcome to engage with the project and carry out their own case studies. Please contact us with your suggestions!

HYDROCOASTAL Outcomes / Participation Invitation

The outcomes of the HYDROCOASTAL will include:

- **State of the art review** of SAR Radar Altimetry and current challenges.
- **Initial SAR / SARin satellite altimeter L2, L3 and L4 Test data set** over 18 Regions of Interest.
- Full descriptions of **processing algorithms** and **output products**.
- **Global Output products**:
  - A Global L2 coastal and inland water SAR altimeter data set.
  - Time series (L3) and river discharge (L4) data sets for medium to large rivers
- A **Scientific Road Map** including recommendations for further developments, implementations and research for SAR altimetry

Thank You – Please get in touch if you are interested!

https://www.satoc.eu/projects/hydrocoastal