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

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The HYDROCOASTAL Project

HYDROCOASTAL is funded by the ESA Science for Society Programme, and is planned to run from Feb 2020 – August 2022, in 4 phases:

1. **Scientific Review & Requirements Consolidation** (Feb-July 2020)
   - State of the art review of SAR and SARin altimeter data processing for coastal zone and inland waters.
2. **Implementation and Validation** (July 2020 – October 2021)
   - Implement new SAR, SARin altimeter processing algorithms to generate a test data set
   - Evaluate performance of the candidate algorithms
   - Generate "global" coastal zone and river discharge data sets
3. **Impact Assessment** (October 2021 – May 2022)
   - Assessments of the global output products through a series of case studies
4. **Outreach and Road Map** (ends August 2022)

Context

The junction between the coastal zone and inland waters is a boundary between

- Different science domains (hydrology, oceanography).
- Different satellite measurement regimes.
- Regions of high variability in small scales.

HYDROCOASTAL aims to enhance understanding of:

- interactions at this boundary,
- the small-scale processes that govern these interactions,
- exchanges with the ocean and the impact on regional sea-level changes.

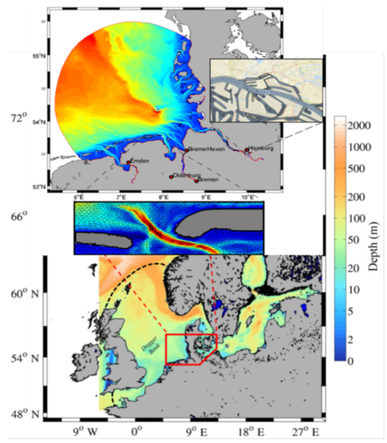


Image courtesy of U Bonn: German Coast of the North Sea and the Elbe Estuary

HYDROCOASTAL SAR Altimeter Test Data Set

The first test data set is being produced to evaluate new L2 processing algorithms over the coastal zone and inland waters, and also processing to L3 (river/lake level time series) and L4 (river discharge)

We have selected 18 Regions of Interest to cover a wide range of inland water and coastal zone characteristics, on all continents (except Antarctica!). The data set will include 2 years data: 2018-2019

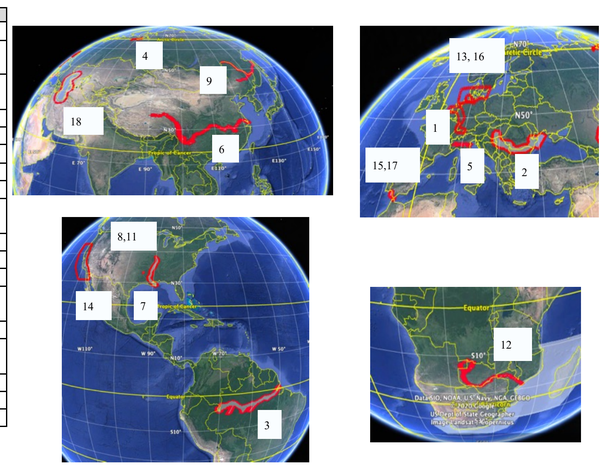
Input data products are CryoSat FBR baseline D SAR and SARin mode data, and Sentinel 3A and 3B SIRAL L1A data

Also enhanced Wet and Dry Troposphere Corrections will be produced by U Porto, and coastal tidal models will be assessed by Noveltis.

Documented descriptions of processing schemes and products available at *www.satoc.eu/projects/hydrocoastal*

First Test Data Set Regions of Interest

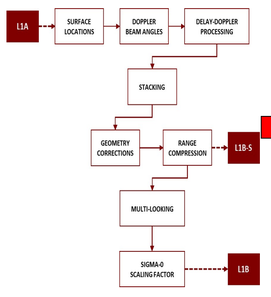
Region	Name	Country	Target Type
TDS1-01	River Rhine	Germany	River
TDS1-02	River Danube	Hungary, Serbia, Romania, Bulgaria	River
TDS1-03	River Amazon – Solimoes	Brazil	River
TDS1-04	River Ob	Russia	River
TDS1-05	River Po	Italy	River
TDS1-06	River Yangtze	China	River, estuary
TDS1-07	River Mississippi	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



Processing to L1B

isardSAT will generate Level 1B-S and Level 1B products as input to processing to L2.

- L1B-S: fully SAR-processed and calibrated SAR complex echoes arranged in stacks after slant range correction and before multi-looking.
- L1B : Geo-located and fully calibrated multi-looked SAR power echoes



Level-1A/Level1-B SAR processing chain (credit: isardSAT)

Candidate L2 Algorithms

Seven candidate L2 processing algorithms will be implemented. Their performance will be evaluated, and based on this, algorithms will be selected to generate global coastal zone and inland water products.

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
7. SCOOP-SAR – Specialised COastal Operator for SAR waveforms – coastal: NOC

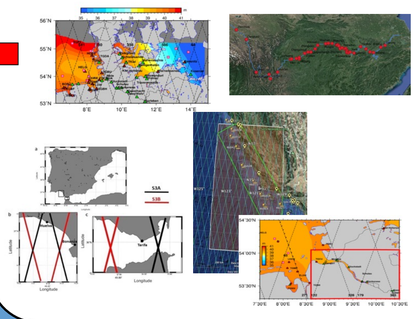
Inland Water L3, L4 Products

The L2 inland water data will be further processed to generate L3 and L4 data products:

- L3 Water Level Time Series
  - L3 products are provided by Alti HydroLab (AHL) and DTU Space
  - Will include river level virtual station products and lake products
  - Products will be on a river basin basis
- L4 River Discharge
  - L4 products are provided by NUIM and CNR-IRPI, initially for the Rhine, Ob, Po, and Mississippi.
  - Both altimetry and near infrared (NIR) imagery is applied to derive discharge

1st Data Set Evaluation

The performance of the different processors at the coast and for inland waters will be evaluated through detailed studies and with a set of agreed metrics.



Coastal Zone -L2
- German Bight /Baltic Sea (U Bonn)
- California Coast / Harvest (NOC)
- Southern Spain (U Cadiz)
- Proximity to Coast (SKYMAT)

Inland Water – L2
- Rhine and Elbe (U Bonn)
- Water Level Time Series (DGFI/TUM)
- Gground-track and water fraction (ATK)
- Amazon Basin (AHL)
- Amur, Yangtze, and Zambezi (DTU)

Inland Water – L3, L4
- Rivers Ob and Rhine (NUIM, U Bonn)
- Rivers Po and Mississippi (CNR-IRPI)

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
- 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"

This "global" product will be made freely available.

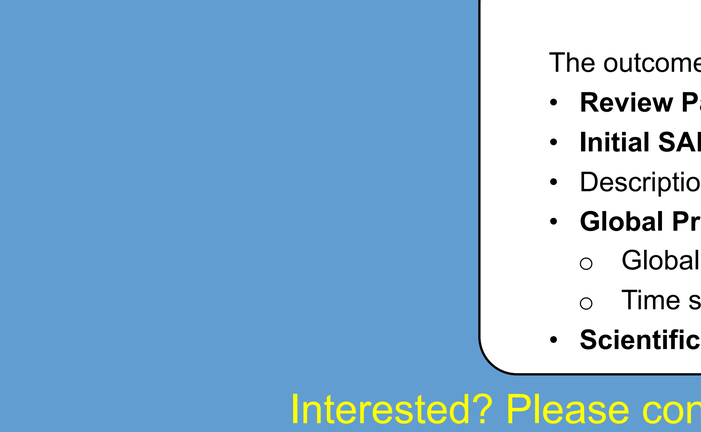
Impact Assessment

In the final year of the project a series of Impact Assessment studies will be carried out, to test demonstrate the potential impact and benefits of the global data set.

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
- Bristol Channel / Severn Estuary (NOC)
- Baltic, German Bight, Elbe Estuary (U Bonn)
- Venice Lagoon (CNR)
- Thailand Coast (TU Delft - with Deltares)
- Ebro River and Delta (isardSAT)

Inland
- Operational Hydrological Forecasting (DTU Env)
- Lake Size, riverbank configuration (NUIM)
- Discharge Validation (CNR)
- Global Water Level Climatology (ATK)
- Wadden Sea study (TU Delft, Deltares

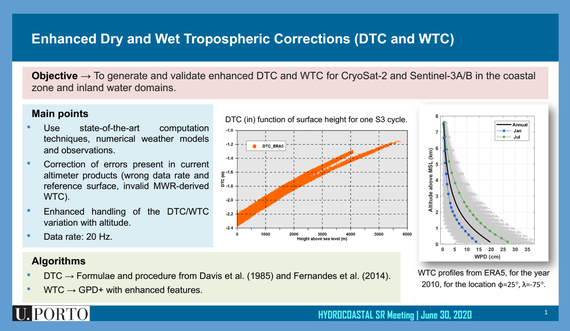


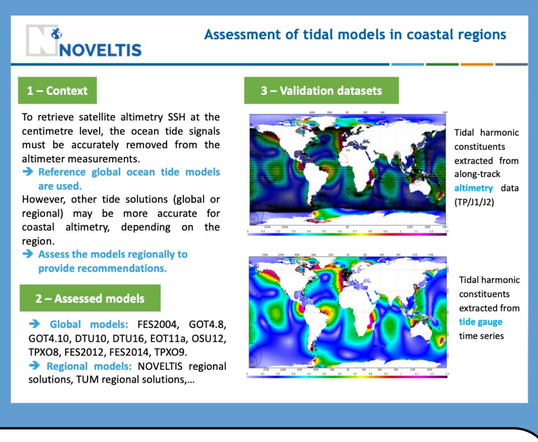
Additional Studies

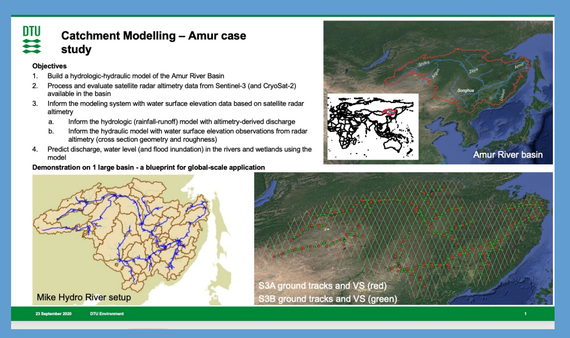
Some additional studies will be carried out in support of the project aims. Panels to the right provide some further detail:

- Enhanced Wet and Dry Troposphere Corrections (U Porto)
- Assessment of coastal tidal models (Noveltis)
- Amur Catchment Study (DTU Environment)

In addition (not presented here) under a new activity funded by a CCN, U Bonn is implementing and evaluating a new SAR altimeter processing scheme which takes into account the vertical motion of wave particles.







HYDROCOASTAL Outcomes

The outcomes of HYDROCOASTAL will include:

- **Review Paper** on state of the art SAR Radar Altimetry.
- **Initial SAR / SARin satellite altimeter L2, L3 and L4 Test data set** over 18 Regions of Interest.
- Descriptions of **processing algorithms** and **products**.
- **Global Products**:
  - Global L2 coastal & inland water SAR altimeter data set.
  - Time series (L3) and river discharge (L4) data sets for medium to large rivers
- **Scientific Road Map** for further developments, implementations and research for SAR altimetry

Interested? Please contact us to access the data and discuss possible applications and case studies

www.satoc.eu/projects/HYDROCOASTAL