Starlab Space

LOTUS WP1 Overview: Processing of SRAL SAR Mode over Oceans

LOTUS – RV4, Brussels
04/02/2016

Starlab
Living Science

WP1 - Processing of SRAL SAR mode waveforms over ocean

- **WP Objectives**
  - Extracting high-resolution sea surface heights (SSH) , wave heights (SWH) and wind speeds from SAR mode data.
  - Apply the RDSAR technique to convert SAR mode data into LRM data to complement the open ocean LRM data sets in the coastal areas.

- **WP Timing**
  - Start: M0
  - End: M12

LOTUS GANTT CHART	Responsible	Start [months]	Due [months]	Start Date	End Date	1 Jan 2013	1 Feb 2013	1 Mar 2013	1 Apr 2013	1 May 2013	1 Jun 2013	1 Jul 2013	1 Aug 2013	1 Sep 2013	1 Oct 2013	1 Nov 2013	1 Dec 2013
MILESTONES						KOM									RV1		
WP1: Processing of SRAL SAR mode wavefors over Ocean																	
Task 1.1: State of the Art Review		0	4	01/01/2013	01/05/2013												
Task 1.2: Scientific Requirements Consolidation		2	4	01/03/2013	01/05/2013												
Task 1.3: Selection of Test Areas		4	5	01/05/2013	01/06/2013												
Task 1.4: Develop Processing for Open Ocean		4	12	01/05/2013	01/01/2014												
Task 1.5: Develop Processing for Polar Ocean		4	12	01/05/2013	01/01/2014												
Task 1.6: Develop Processing for Coastal Zone		4	12	01/05/2013	01/01/2014												

Tasks

- **WP Team**
  - WP Leader: Starlab
  - Collaborators: CLS, DTU, DMU, DHI

- The work to be done in this work package will be **subdivided per sub-themes**.
  - **Open ocean** [lead by CLS, with the support from STARLAB]
  - **Polar ocean** [lead by DTU]
  - **Coastal zone** [lead by STARLAB, with the support from CLS]

- **List of Activities**
  - Task 1.1: State of the Art Review [STARLAB]
  - Task 1.2: Scientific Requirements Consolidation [CLS]
  - Task 1.3: Selection of Test Areas [STARLAB]
  - Task 1.4: Develop Processing for Open Ocean [CLS]
  - Task 1.5: Develop Processing for Polar Ocean [DTU]
  - Task 1.6: Develop Processing for Coastal Zone [STARLAB]

Deliverables & Milestones - Status

- D1.1 SAR mode for Ocean State of the art review [STARLAB] – M4
  - Deliverable submitted and **accepted**
- D1.2 SAR mode for Ocean Scientific Requirements [CLS] – M4
  - Deliverable submitted and **accepted**
- D1.3 SAR mode for Ocean Algorithms Theoretical Basis Document – M12
  - Deliverable **accepted**

LOTUS GANTT CHART	Responsible	Start [months]	Due [months]	Start Date	End Date	1 Jan 2013	1 Feb 2013	1 Mar 2013	1 Apr 2013	1 May 2013	1 Jun 2013	1 Jul 2013	1 Aug 2013	1 Sep 2013	1 Oct 2013	1 Nov 2013	1 Dec 2013
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Task 1.1: State of the Art Review [STARLAB]

- **Timing**: M0 → M2
- **Task objective**: Review of state of the Art for open ocean, polar ocean, coastal zone altimetry
- **Activities**:
  - (a) Review of existing algorithms to process SAR mode data over ocean
  - (b) Review of available corrections, and their status, for the derivation of ocean geophysical parameters from SAR mode
  - (c) Review of existing algorithms to derive RDSAR data from SAR mode
- **Outputs**:
  - D1.1 SAR mode for Ocean State of the art review
- **Contributors**:
  - Open ocean: CLS, STARLAB
  - Polar ocean: DTU
  - Coastal zone: STARLAB, CLS

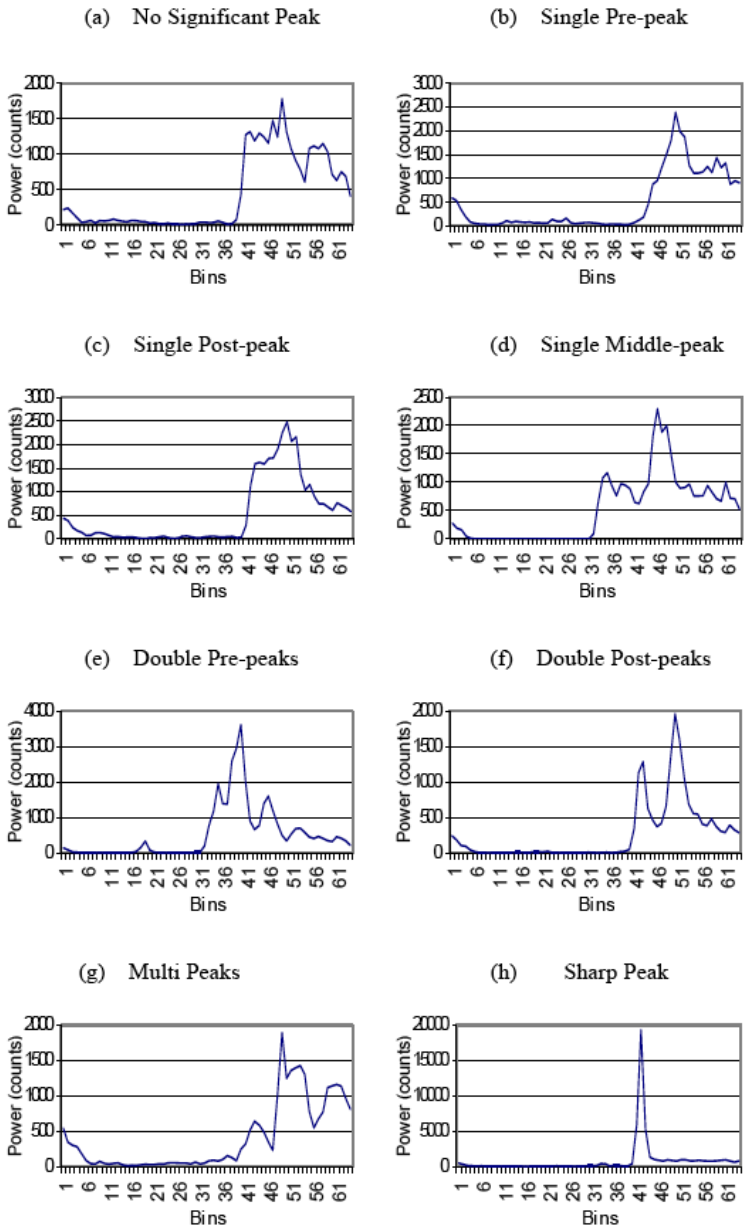
SAR Altimetry for Open Ocean

- **Technology Status**
  - Cryosat-2: First SAR Altimetry mission
    - devoted for ice but 12% of open ocean is covered with SAR mode
  - Next delay/Doppler Altimeters: SRAL in Sentinel-3, and Poseidon-4 aboard Jason-CS
- **Retracking Algorithms**
  - Semi-analytical model for Doppler altimetry (CNES/CLS)
    - PTR numerical computation to avoid approximations
    - Gaussian approximation of antenna gain
  - Numerical retracking algorithm (**CPP**, CNES)
  - Numerical retracking algorithm (CLS)
  - Analytical retracking algorithm, **SAMOSA** (Starlab, within ESA contracts)
    - SAMOSA v1, 2, 3…

SAR Altimetry for Coastal Zones

Land Contamination Effects

- **Land contamination**: Principal distortion effect of altimeter waveforms near the coast
- Depends on the relative weight of the power coming from the land and the ocean.
- The geometry and orientation of the coast with respect to the satellite track contribute to create an undetermined number of possible radar echoes



Deng, 2003

SAR Altimetry for Coastal Zones

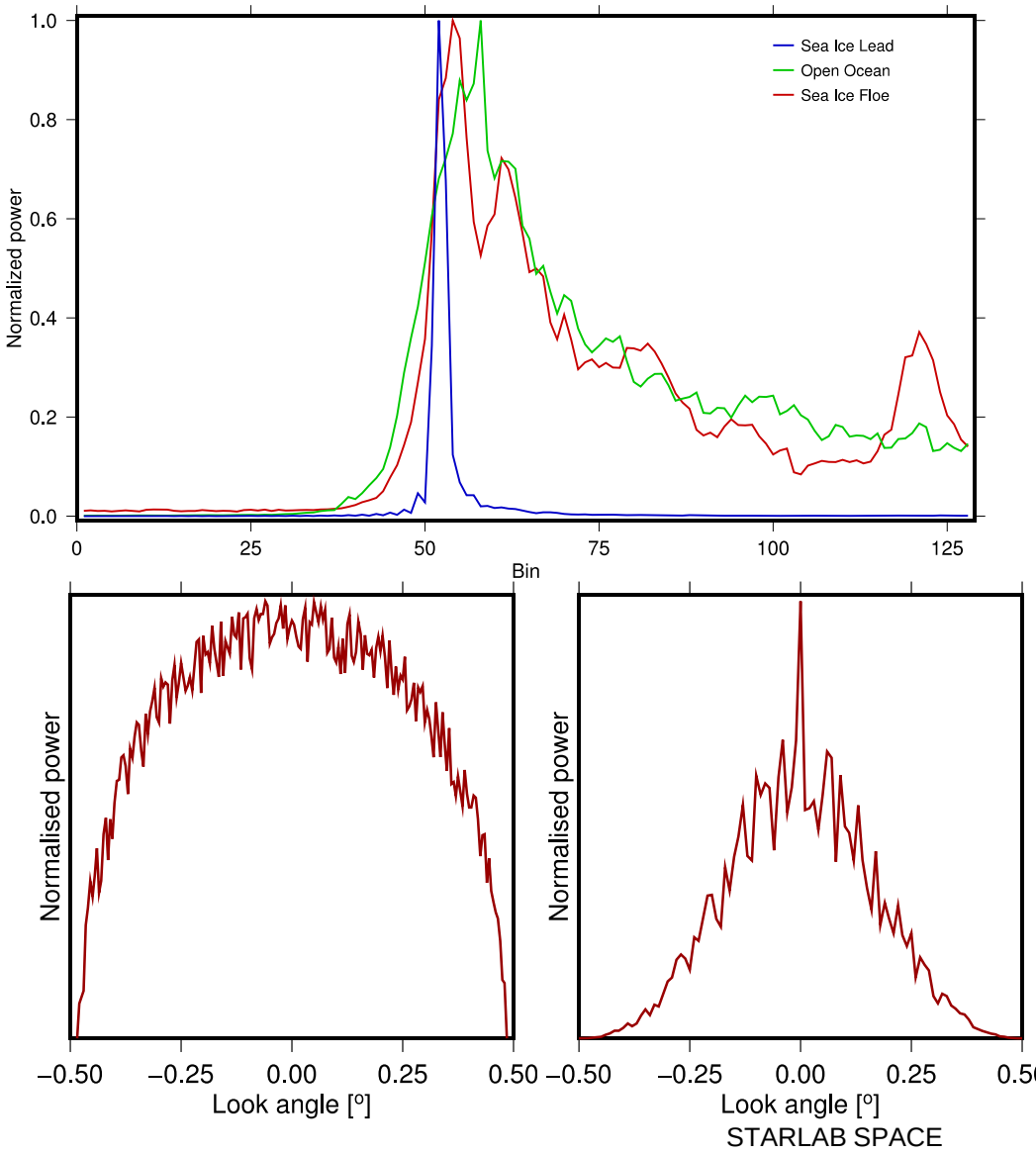
Retracking Technique Status (Conventional Altimetry)

- PISTACH and COASTALT projects have investigated suitable solution to reduce the effect of land contamination on altimeter echoes
  - COASTALT:
    - Hyperbolic pretracker to eliminate possible effect of land scattering on radargram.
    - Physical retracker to account for the combined effects of land and sea scattering on final echoes.
  - PISTACH:
    - SWH and SSH estimation from waveform bins unaffected by land contamination

SAR Altimetry for Polar Ocean

Echoes Classification

- Due to the effect of different scattering geometries the radar echoes present very different shapes
- **Pulse classification** technique developed by DTU based on the analysis of delay/Doppler stack power distribution
  - Technique under development
- This initial classification allows to perform the retracking of the specular-like waveforms



Task 1.2 : Scientific Requirement Consolidation [CLS]

- **Timing**: M2 → M4
- **Task objective**: Define a consolidated list of scientific requirements to adapt current algorithms
- **Activities**:
  - (a) Define consolidated scientific requirements to adapt current algorithms to Sentinel-3
  - (b) Identify scientific constraints for the methods and models
  - (c) Define consolidated scientific requirements to enhance current available corrections
- **Outputs**:
  - D1.2 SAR mode for Ocean Scientific Requirements
- **Contributors**:
  - CLS

Requirement Consolidation from previous experience

- **CP4O**: The experience of LOTUS team members with CS-2 data processing (in particular the CP4O project which is an ESA project aiming at comparing different processing on test areas)

- **STM Simulators**: Knowledge of the S3 ground processing (CLS has been a member of the core team led by Thales AS involved in the development and procurement of the end-to-end Surface Topography Mission (STM) Simulators.

- **L2 prototype**: CLS also led a consortium to define and develop the L2 prototype (for SRAL and MWR) in the frame of an ESA-ESRIN/CNES program). CLS is now responsible of the development of the S-3 Instrument Processing Facility (in a contract led by ACRI for ESA)

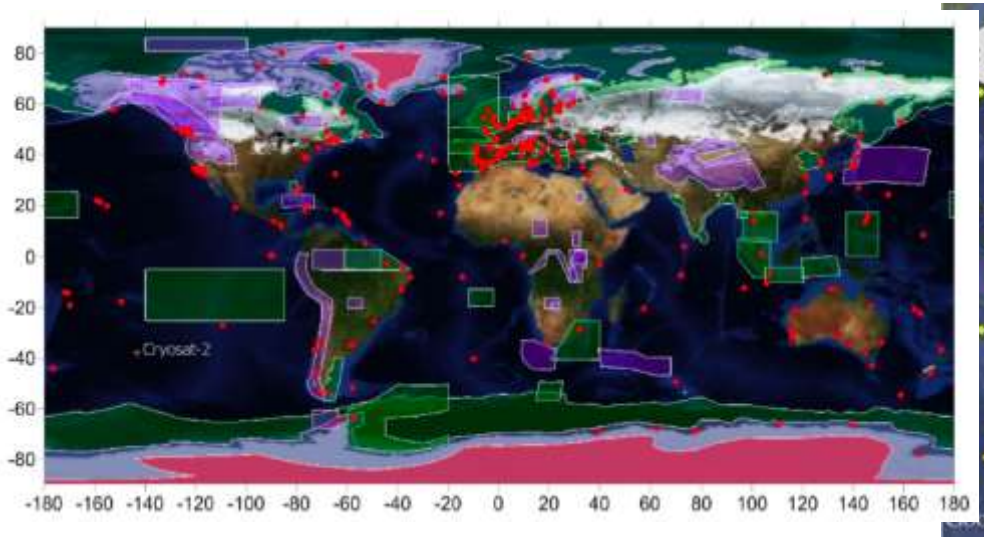
- **LOTUS outputs**: Output of task 1.1

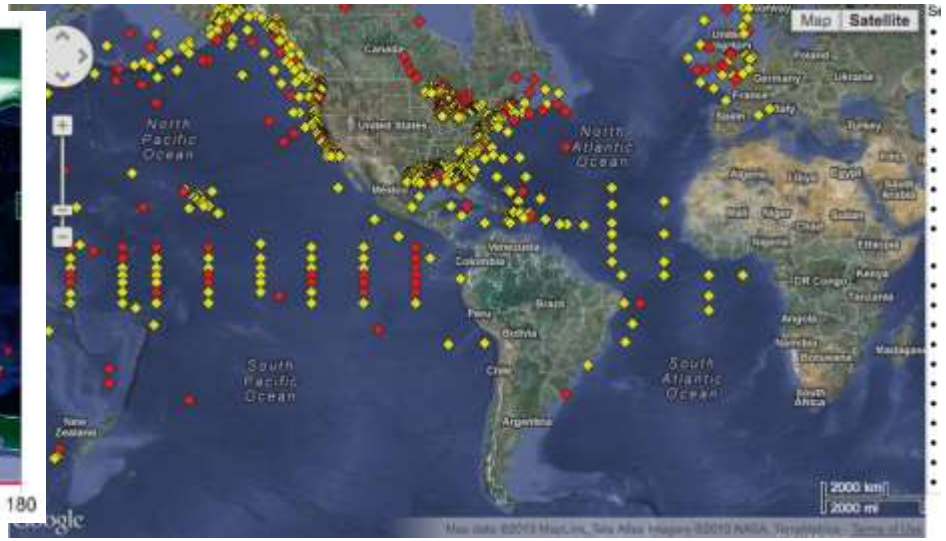
- **Literature**: Literature review

Task 1.3 : Selection of Test Areas [STARLAB]

- **Timing**: M4 → M5
- **Task objective**: Selection of areas for validation activities
- **Activities**:
  - (a) Define list of potential test areas of the ocean for the focus areas:
    - Open Ocean
    - Polar Ocean
    - Coastal zone
  - (b) Asses availability of independent data set for validation
- **Outputs**:
- **Contributors**:
  - Open Ocean (CLS)
  - Polar Ocean (DTU)
  - Coastal zone (STARLAB)

Test areas selected – Open ocean, Coastal Zone, Polar ocean





Application	Areas	
Open ocean	NE Atlantic	13W – 15E, 48N, 59N
	Adriatic Sea	12E – 20E, 40N – 46N
	Bay of Singapore	98E – 121E, 4S – 25N
Coastal zone	NE Atlantic + North Sea	13W – 15E, 48N, 59N
	Adriatic Sea	12E – 20E, 40N – 46N
Polar ocean	North pole	60N – 90N
	Svalbard	0E – 40E, 75N – 85N

Task 1.4 : Develop processing for Open Ocean [CLS]

- **Timing**: M2 → M12
- **Task objective**: Develop SAR algorithms for Open Ocean data
- **Activities**:
  - SAR mode algorithm improvements for :
    - (a) RCS retrieval
    - (b) Range, Significant waveheight and RCS precision improvement.
  - RDSAR adaptation for Sentinel-3 data
  - Processing of SAR mode data and RDSAR data
- **Outputs**:
  - D1.3 SAR mode “Algorithms and Theoretical Basis Document” for Open Ocean
- **Contributors**:
  - CLS

Task 1.4 : Develop processing for Open Ocean [CLS]

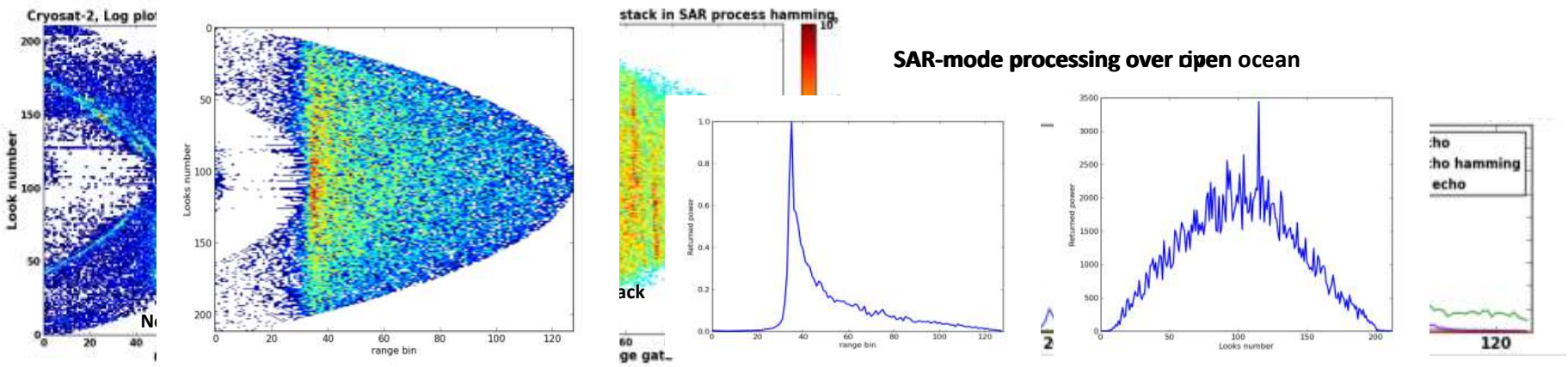
- In the frame of the LOTUS project, CLS has undertaken several studies for producing innovative SARM products over open ocean thanks to the availability of Cryosat-2 data:
  - To develop processing methods to **improve SARM retrievals over ocean surfaces**
  - To **assess SARM processing performances**
  - To define how to **ensure data quality continuity between SARM and LRM**
  - To **provide a LRM reference** (so called PLRM) during SAR-mode to calibrate SAR results

➔ **To form new innovative Copernicus products (and applications) utilizing the full potential of SAR-mode**

➔ **In order to prepare the Sentinel-3 mission**

Task 1.4 : Develop processing for Open Ocean [CLS]

- Development of a Cryosat processing prototype chain (inherited from CPP)
  - Producing Level 1 and 2 (corrected and calibrated) LRM/PLRM/SARM data from FBR over ocean (but also inland waters and ice sheets)
  - SARM processing have been investigated
    - Range migration
    - different stacking approaches
    - oversampling SAR/LRM waveforms (➔ **presented at OSTST 2014**)
    - along-track Hamming weighting function (specific for land/coastal applications)
  - Different outputs are produced
    - L1BS (stack of co-located Doppler beams)
    - L1B averaged waveforms (Multilooked SAR power echo and distribution of power among looks in the stack)



Task 1.4 : Develop processing for Open Ocean [CLS]

- Development of Level-2 algorithms and methods
  - To estimate geophysical parameters from SARM numerical and semi-analytical retrackers
  - To compute LRM/PLRM correction tables for correcting estimations (range, swh) issued from analytical retracking algorithms
  - To estimate the angular biases between the star tracker boresight and the altimeter electromagnetic axis
  - To estimate moments of the distribution of power in the stack with statistical and retracking method (➔ **presented at OSTST 2014**)
  - To implement the geophysical/environmental corrections
  - High-wind response and SAR/PLRM SSB corrections computation

- Producing long-time series data (>2 years)
  - To allow the detection of residual orbit and others long-term errors, and also long-term drifts (LPF, angular biases with star trackers, …)
  - To allow comparison and validation with others altimeters (Envisat, Jason-2, Altika,.. Sentinel-3)
  - Synergy with CP4O projects: focusing on the comparison between different SARM/PLRM retracker solutions (➔ **presented at OSTST 2014**)

Task 1.5 : Develop processing for Polar Ocean [DTU and UNEW]

- **Timing**: M2 → M12
- **Task objective**: Develop SAR algorithm for Polar Ocean data
- **Activities**:
  - Investigate existing and suggest alternative methods for detection of open water leads in sea ice covered regions
  - Investigate existing and suggest alternative methods for range retrieval in sea ice covered regions
  - Processing of SAR mode data
- **Outputs**:
  - D1.3 SAR mode “Algorithms and Theoretical Basis Document” for Open Ocean
- **Contributors**:
  - DTU, UNEW

Task 1.5 : Develop processing for Polar Ocean [DTU and UNEW]

Polar ocean waveforms retracking has been improved using different retrackers for each classified waveforms. The classification is based on the Pulse Peakness (PP) and the Stack Standard Deviation (SSD). Three retrackers are, then used:

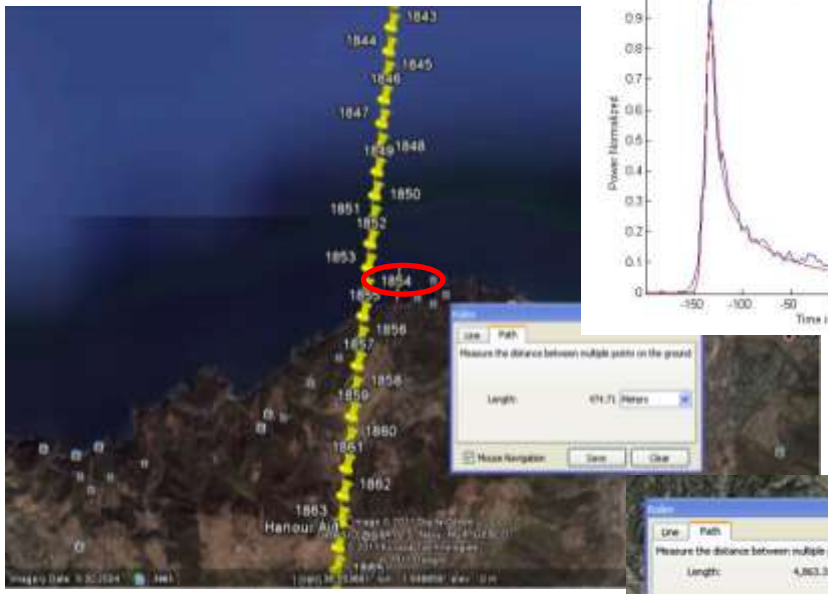
- SAMOSA3 for Open Ocean waveforms (normal ocean waveform)
- SAMOSA3 adapted retracker for Leads (specular waveform)
- Primary Peak empirical threshold retracker for sea-ice floes or melange (remaining waveforms)

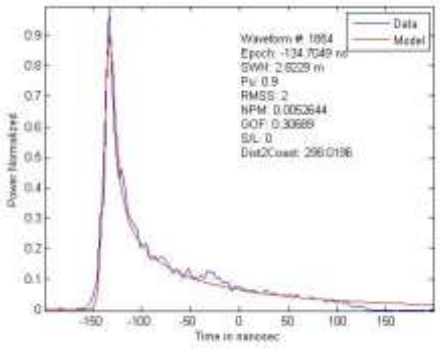
Task 1.6 : Develop processing for Coastal Zone [STARLAB]

- **Timing**: M2 → M12
- **Task objective**: Develop SAR algorithm for Coastal Zone
- **Activities**:
  - Adaptation of Open Ocean SAR mode models to coastal zones
  - Coastal Zone algorithms adaptation to Sentinel-3
  - Processing of SAR Mode data for coastal scenarios; processing of RDSAR data for comparison and cross-validation
- **Outputs**:
  - D1.3 SAR mode “Algorithms and Theoretical Basis Document” for Open Ocean
- **Contributors**:
  - STARLAB

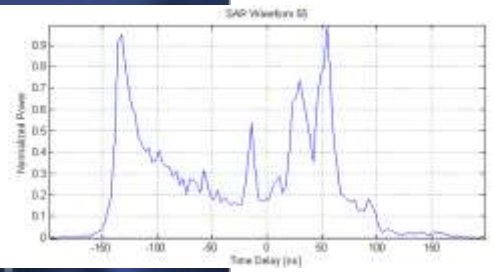
SAR Altimetry for Coastal Zones

SAR processing limitations in coastal areas





Images Courtesy: S. Dinardo, ESA

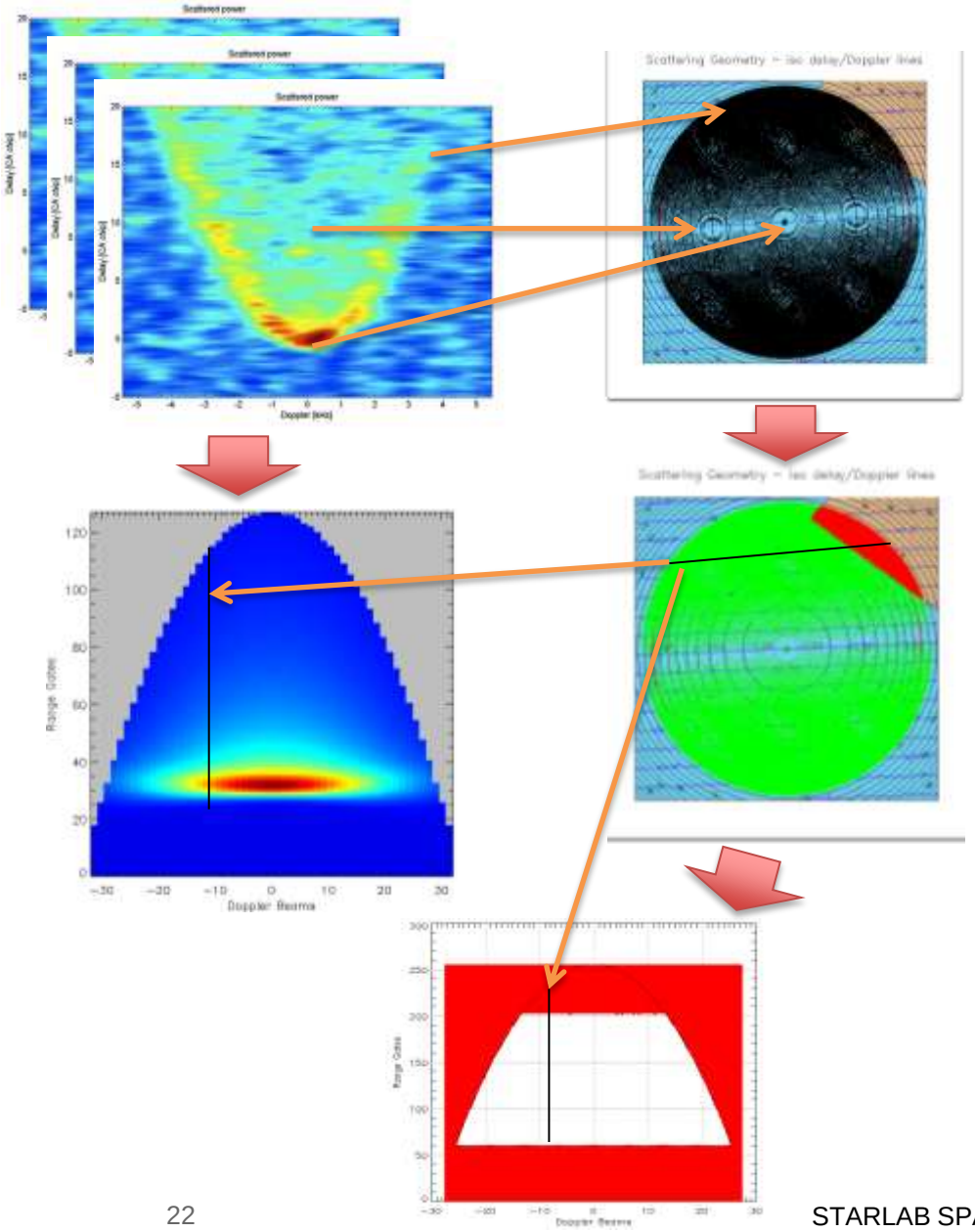


SAR Altimetry for Coastal Zones

SAR preprocessing

- Processing approach based on Stack analysis:
  - Delay/Doppler technique allows to generate a 2D map on the surface of backscattering response
  - **Geo-referencing of Stack**

- Apply **Land mask** to suppress delay/Doppler bins potentially affected by land contamination effects

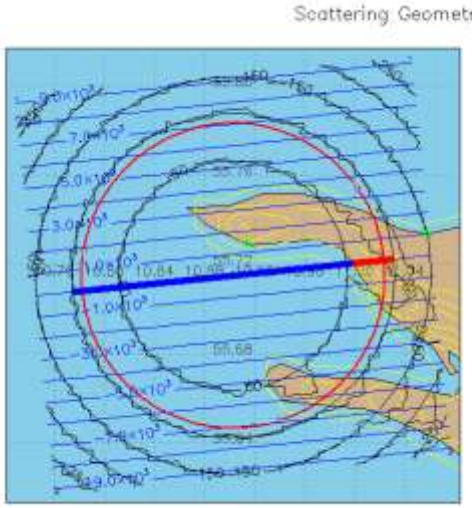


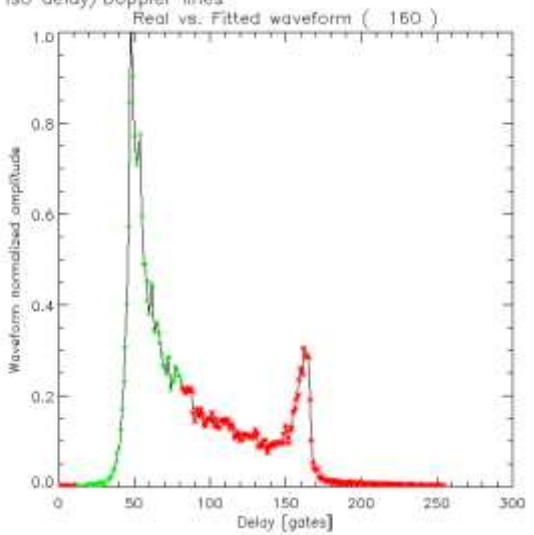
SAR Altimetry for Coastal Zones

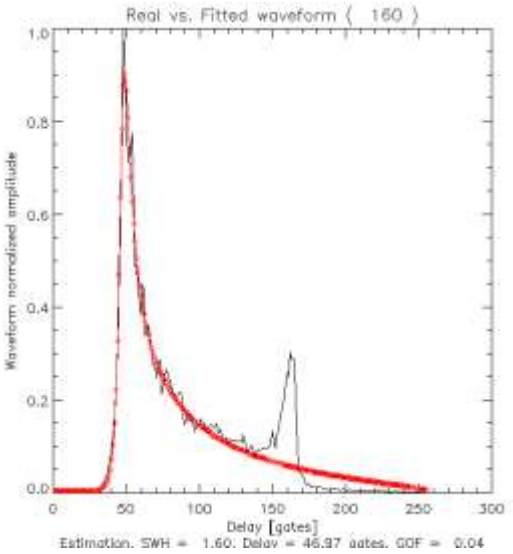
Waveforms retracking

- Waveform stack **preprocessing**
  - Discard delay/Doppler bins potentially affected by land contamination effects

- SAR SAMOSA **retracker**
  - Retrack cut waveforms through SAMOSA retracker to get fitted waveform and physical parameters SSH, SWH, Backscatter coefficient







Conclusion

Open Ocean

- Development of a Cryosat-2 Processing chain (L1B, L1BS)
- Development of level-2 algorithms and methods
- Producing long-time series
- New innovative Copernicus products preparing for Sentinel-3

Coastal Sea

- Retracker pre-processing discarding backscattering power contributions from lands.

Polar Ocean

- SAMOSA3 retracker adaptation for Leads (specular waveform)
- Primary Peak empirical threshold retracker improvements for sea-ice floes or melange (remaining waveforms)

Thank you for your attention

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