

SCOOP WP1000

Scientific Review and Requirements Consolidation

Led by NOC, with CLS, SatOC, isardSAT, UPorto

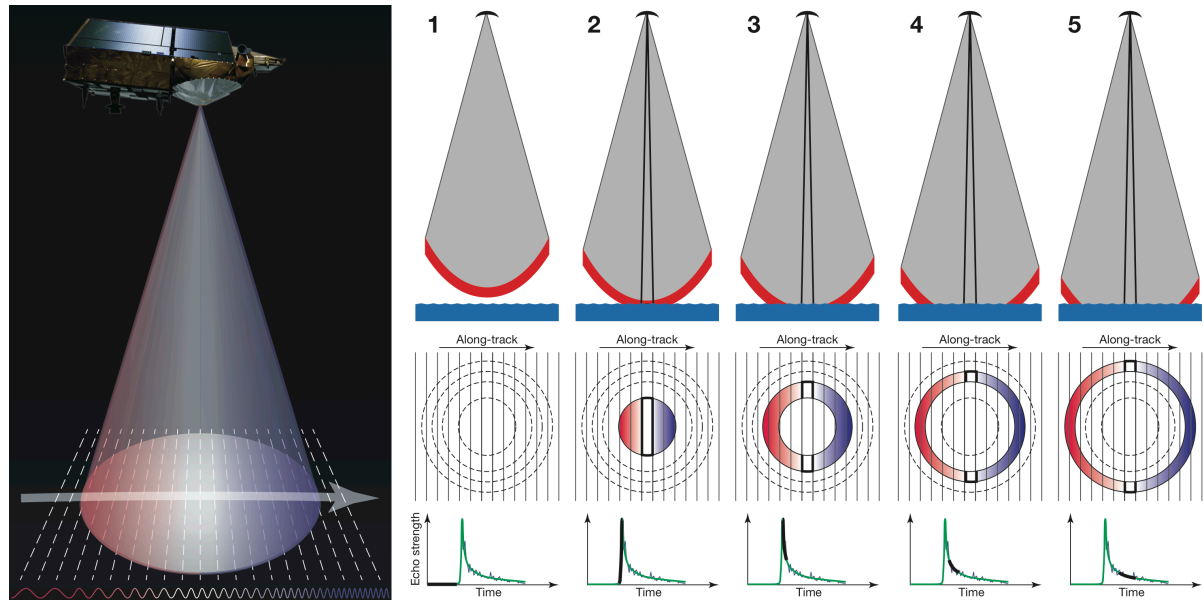


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Overall WP1000 Objective

- Review state of the art in SAR altimetry and provide recommendations
 - input datasets
 - methods
 - specific algorithms
- Those are used for generation of test dataset



Sub-Workpackages and Deliverables

- WP1100 SAR Altimetry Scientific **Review**
- WP1200 Critical Review of the Technical **Requirements**
- WP1300 – First draft of the **Algorithm Theoretical Basis Document(s)**
- WP1400 – Compilation of the **Processing Options Configuration Control Document (POCCD)**

Status

- WP1100
 - baseline knowledge and review of 2013-2015 progress carried out by NOC
 - L1a to L1b state of the art reviewed and detailed by isardSAT
 - L1b to L2 work, and collation of recommendations work in progress by NOC
 - first draft (v0.2) just circulated for comments and discussion at this workshop and in the following days
 - update by end of this week
 - please feed comments by 5 Feb, for final release by Feb 9
 - eventually turn into a paper? TBD

Status (cont.)

- WP1200
 - L1a to L1b requirements provided by isardSAT with back-mapping into SoW requirements
 - needs streamlining and remapping into new requirements for data production (forward-mapping)
 - L1b to L2 requirements being written by NOC
 - will solicit qualified, target-specific input from partners
 - Geographical ROI cataloguing has been coordinated by isardSAT
 - Note Harvest region added (31-38N, 119-124W) to C2 SAR mode mask as requested by Noveltis after KO
 - Current C2 SAR patch portfolio covers wide range of conditions
 - Draft by Feb 3, comments Feb 9, final release Feb 12

Status (cont.)

- WP1300 ATBD
 - RDSAR algorithms to be provided by TU Delft
 - L1a to L1b algorithms already provided by isardSAT
 - L1b to L2 algorithms provided by STARLAB
- WP1400 POCCD
 - same sections as ATBD
 - TBD following recommendations in TN1

WP1100 – State of the art

- Based on
 - project reports
 - contributions at meetings and conferences
 - recent peer-reviewed literature

a critical review is being carried out of the characteristics and performance of the methods and algorithms that have been implemented in processing SAR altimeter data.

- From this review, **recommendations** are being drafted on the approaches / schemes to be implemented in processing SAR data to generate the Test Data Sets for this project

Inputs

- Starting point: SAR expert group meeting, NOC June 2013 (Gommenginger et al)
- OSTST & CAW 2013/14/15
- CP40 findings and **final 'scientific roadmap'**
- SAR mode literature up to Oct 2015



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EUMETSAT CALL-FOR-OFFER 205721

JASON-CS SAR MODE ERROR BUDGET STUDY
REVIEW OF STATE OF KNOWLEDGE FOR SAR
ALTIMETRY OVER OCEAN

CHRISTINE GOMMENGINGER¹
CRISTINA MARTIN-PUIG², LAIBA AMAROUCHE³
& R. KEITH RANEY⁴

¹NATIONAL OCEANOGRAPHY CENTRE – SOUTHAMPTON, UK;
²ISARDSAT, SPAIN; ³COLLECTE LOCALISATION SATELLITES, FRANCE;
⁴2KR-LLC, USA

EUMETSAT REFERENCE: EUM/RSP/REP/14/749304

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VERSION 2.2

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NATIONAL OCEANOGRAPHY CENTRE, SOUTHAMPTON
EUROPEAN WAY, SOUTHAMPTON SO14 3ZH

Gommenginger et al. Review 2013

- Evidence of clear benefits from SAR Alt on C2:
 - measurement noise diminished both for SSH and SWH;
 - transitions at mode switch are smooth
 - the spectral description of SSH at short ocean wavelengths is improved (no ‘bump’);
 - better coastal data (TBC more qualitatively)
- Comprehensive review of wf & retracking models
 - empirical, numerical, semi/analytical and fully-analytical (incl SAMOSA3 for S3 DPM)
- Comprehensive review of RDSAR techniques

Gommenginger et al. Review 2013

- Strong Interleaved SAR mode recommendation for Jason-CS
 - of relevance to SCOOP group: is this still possible for S-3 C/D ???
- number of issues that were undergoing (or required) further investigations;
 - sensitivity to platform mispointing
 - the lack of a Sea State Bias (SSB) in SAR mode
 - the effects of swell and swell direction
- discussion on some technical aspects missing as it was just starting at that time
 - windowing in azimuth, zero-padding, ‘peeling’ of the stack prior to multi-looking, etc

CP40 scientific roadmap

- **SAR Processing Issues**
 - SAR Waveform
 - Under-sampling peaky waveforms
 - Optimising Doppler processing /selection / weighting
 - Purpose /optimisation of Windowing
 - SAMOSA implementation (PTR, Thermal noise)
 - SAR waveform blurring at high alt rates
 - RDSAR Processing
 - Effect of SAR transmission pattern on waveform statistics
 - How to improve waveform statistics / minimize use of correlated echoes
- **Investigations into SAR Altimetry Characteristics**
 - SWH dependencies / errors
 - Impact of swell
 - Development and evaluation of SAR mode SSB models
 - Dependence of retrieved parameters on roll angle, pitch angle, radial velocity
 - Characteristics of Full Bit Rate echoes, stack data

Key progress points at L1

- **stack issue 1**: how to weight outer doppler bins
- CLS weighted MLE3 retracking gives more importance to portions of the waveform with low power
 - so next step is to weight the doppler beams too
- the concept of a “weighting-up” of the outer doppler beams is also present in the AC/DC approach, see later

Key progress points at L1

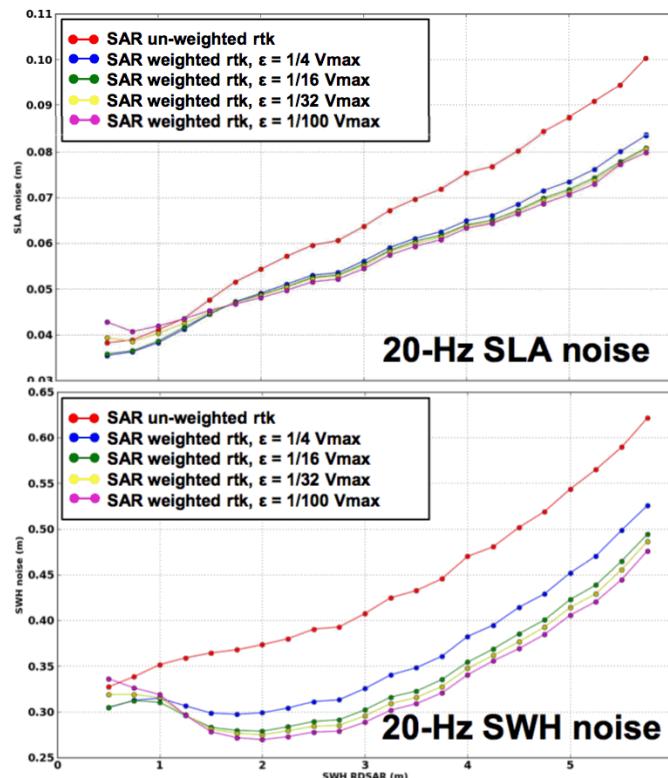
OPTIMISED SAR OCEAN NUMERICAL RETRACKING

- A weighted MLE3 retracking (aka **Maximum-likelihood estimator algorithm**) gives more importance to portions of the waveform with low power

$$B_{mk} = \frac{1}{P_u} \frac{\partial V_k}{\partial \theta_m} \quad \Rightarrow \quad B_{mk} = \frac{1}{V_k + \varepsilon} \frac{\partial V_k}{\partial \theta_m}$$

$$D_k = \frac{V_k - \tilde{V}_k}{P_u} \quad \Rightarrow \quad D_k = \frac{V_k - \tilde{V}_k}{V_k + \varepsilon}$$

V_k echo model in power
 \tilde{V}_k measured waveform
 ε positive constant to prevent instabilities and numerical convergence issues
 k samples from 0 to 127
 m parameters (τ , swh, P_u)



Analysis of 1-month Cryosat-2 data

- Higher bias for low ε
 - No significant bias for $\varepsilon = \frac{1}{4} V_{max}$
 - 20-Hz noise reduction ($\varepsilon = \frac{1}{4} V_{max}$)
 - SLA 10% (SWH @2m)
 - SWH 20% (SWH @2m)
 - Sigma0 25% (SWH @2m)
- Same oceanic signal content (from spectra analysis)

➔ A likelihood estimator weighted in Doppler beams would provide more improvements

Key progress points at L1

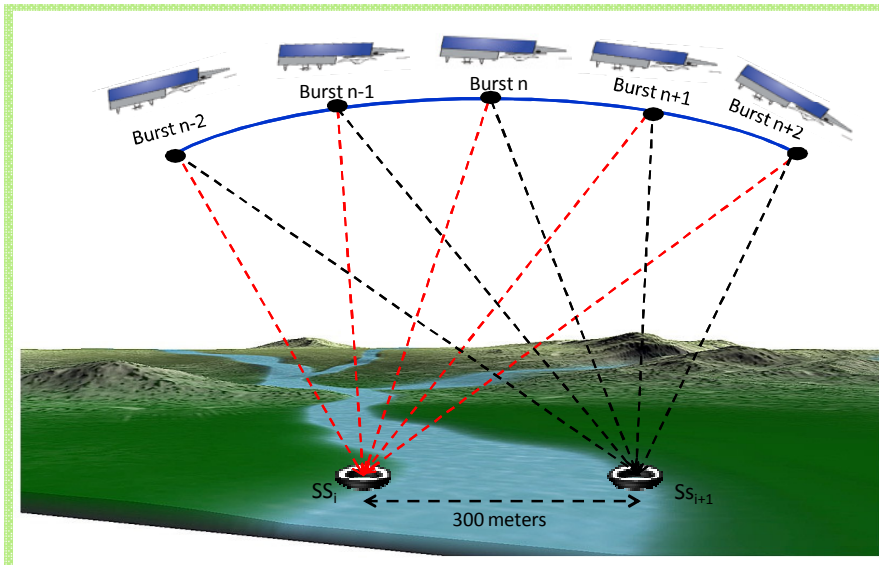
- **stack issue 2:** exploiting the distribution of power in the stack
 - use for mispointing (Moreau et al OSTST2014)
 - use for pitch estimation (Scagliola et al GRSL 2015)

 - mispointing also can be derived from stack in the AC/DC approach

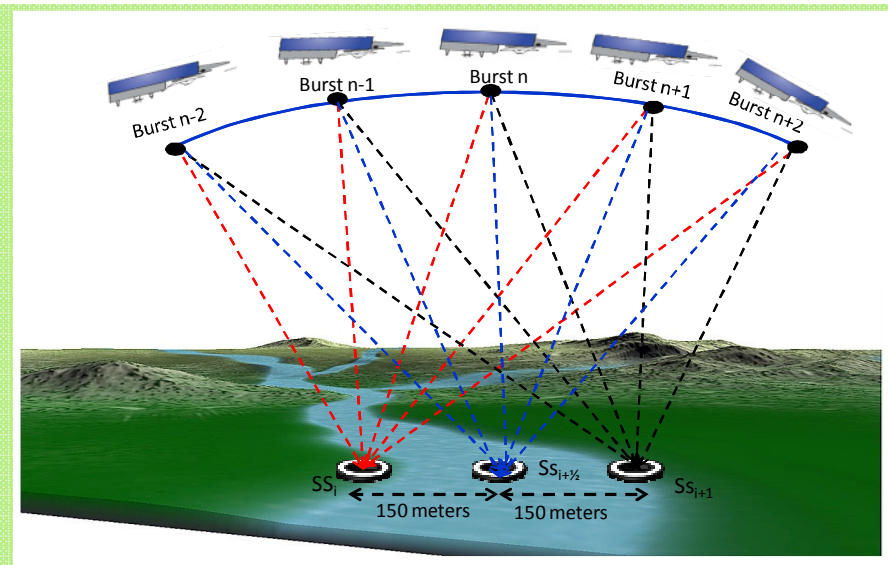
- **stack issue 3:** individual doppler retracking (Moreau et al OSTST2015)
 - to be explored in SCOOP

Key progress points at L1

- computation on a finer ground step (Dinardo et al CAW2013, OSTST2015)
 - ~80 Hz natural choice (burst repetition frequency)
 - datation time and geo-location information are provided at each burst center in the FBR products



The ground cells are localized on river banks: potentially we miss to observe the river cross center....



Now, we steer the Doppler beams at the river cross center: a new measurement exactly at river cross center is now achieved !

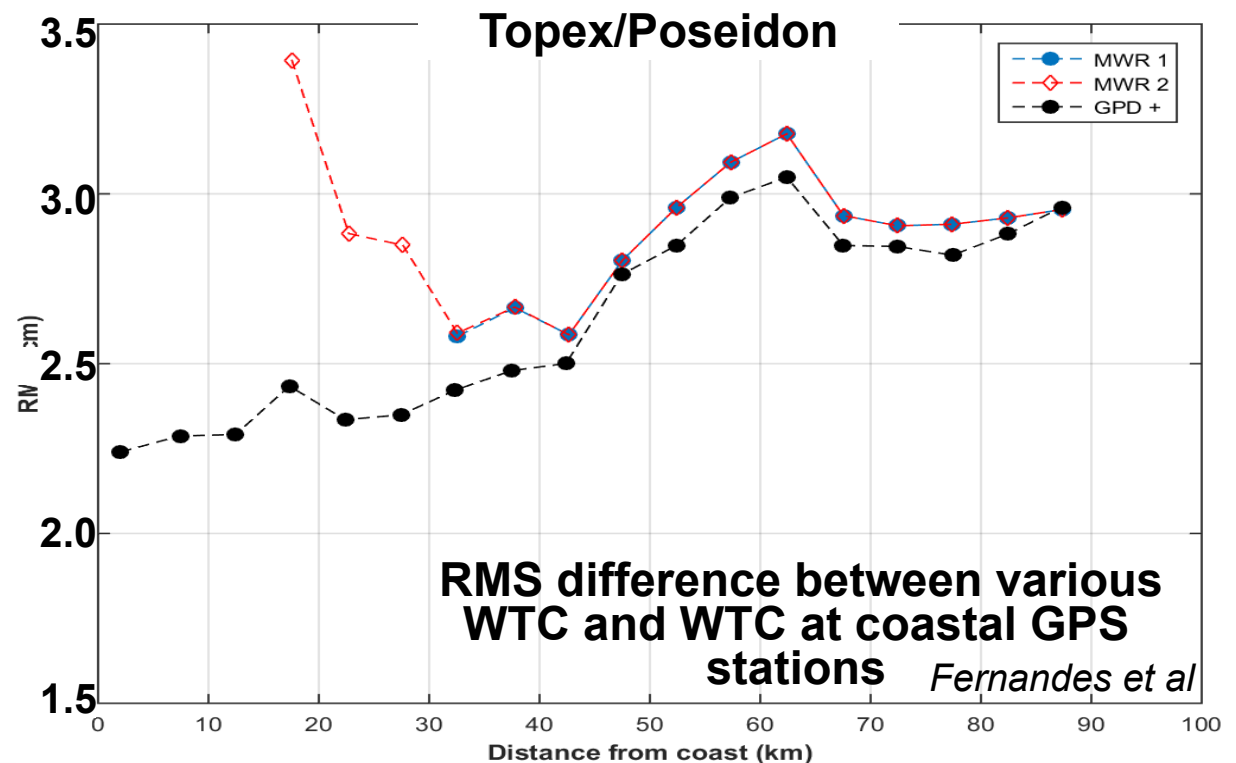
Key progress points at L2

- Improvements in SAMOSA models
 - comprehensive details presented by Roca et al at CAW/OSTST2013, Martin-Puig et al at OSTST2014
 - L2 now adapted to any kind of SAR mode processing

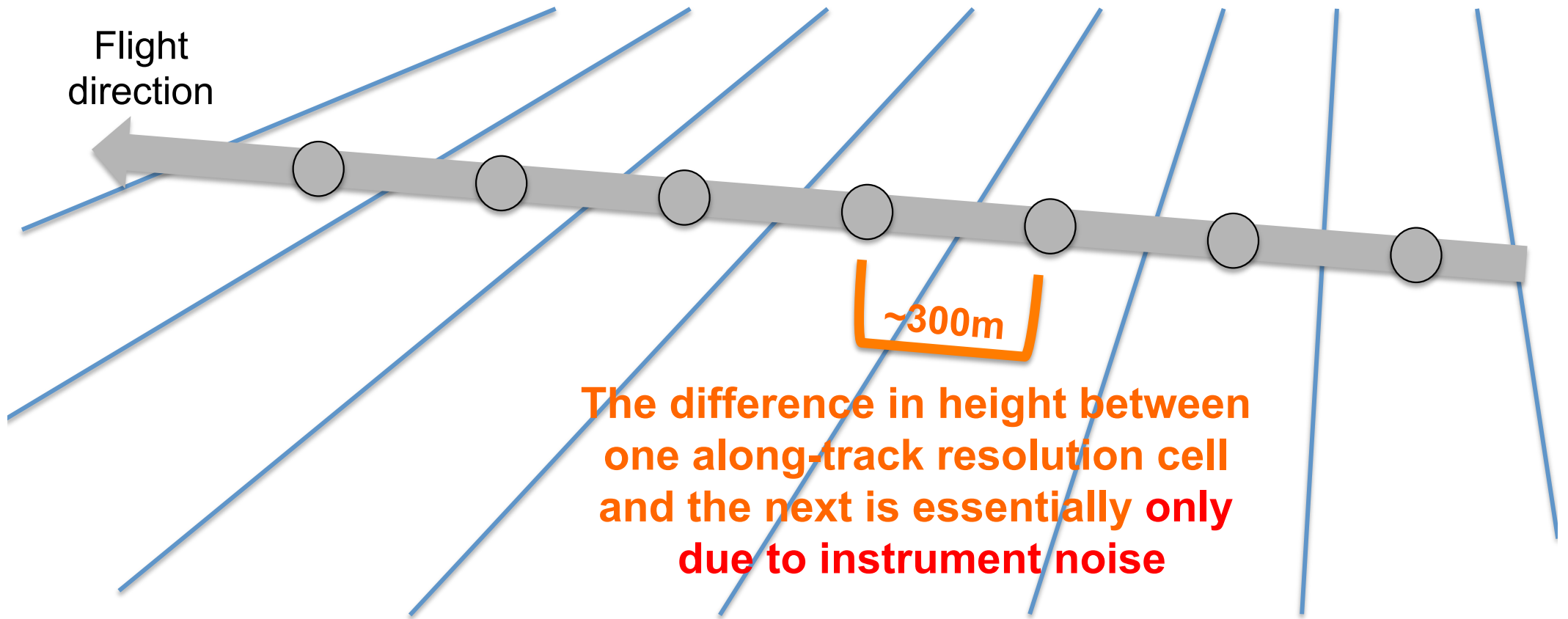
- SAR/SSB issues still much open!

Key progress points - corrections

- Great improvement in Wet Tropo: GPD+ (UPorto)
 - from Alt MWR, ~700 GNSS stations, imaging MWR
 - available globally for 8 missions, great improvement at the coast, significant impact on regional sea level trends



Assessing SAR mode performance

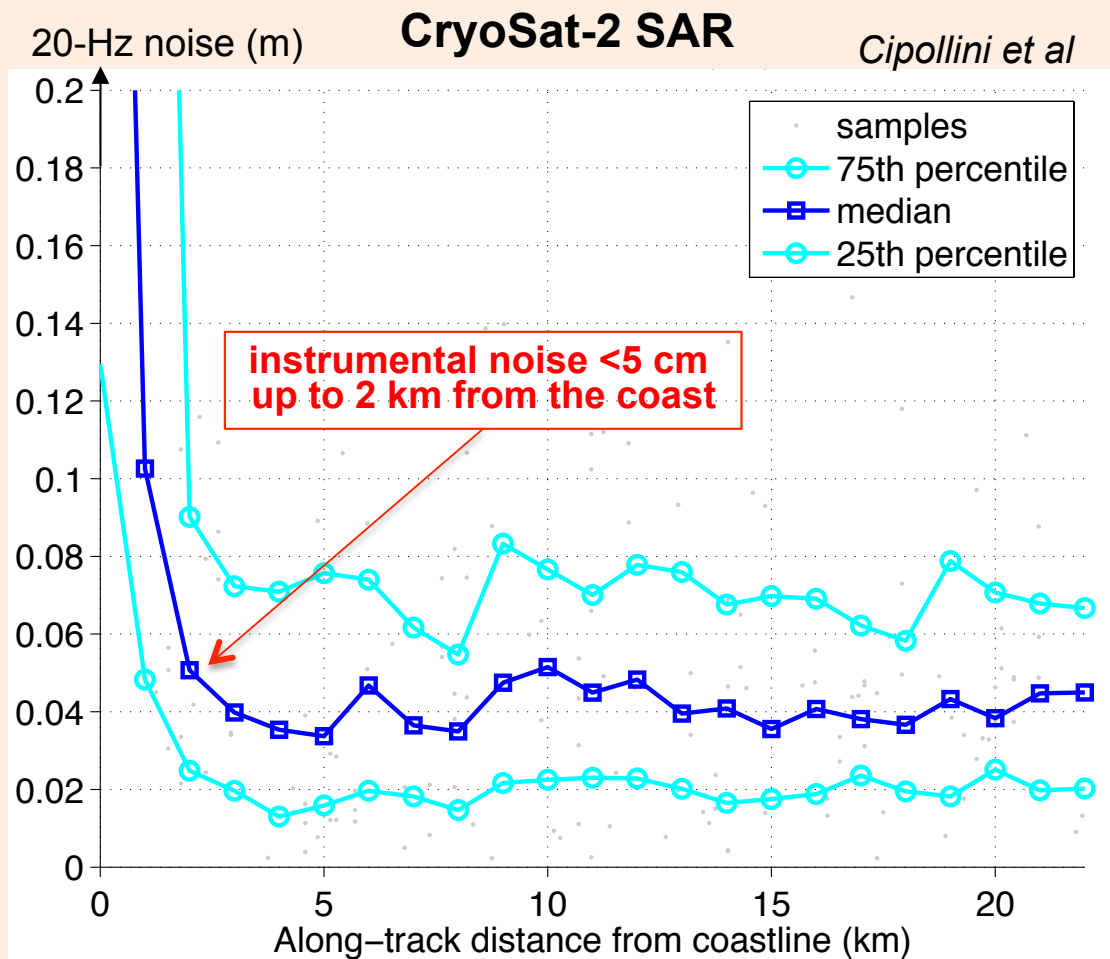
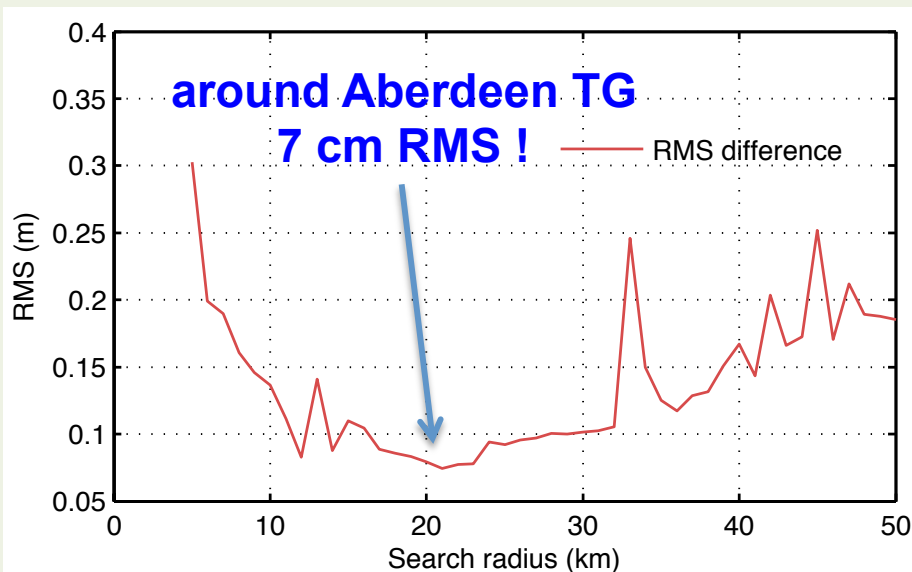


We use the absolute value of this difference as an indication of noise in that particular location along the track

Key progress points - coastal

Quantitative analysis shows excellent performance

Validation against tide gauges ongoing and very encouraging:
RMS < 10 cm with search radii around ~20 km



Data from "Brighton Box" (South UK) processed by GPOD @ ESRIN

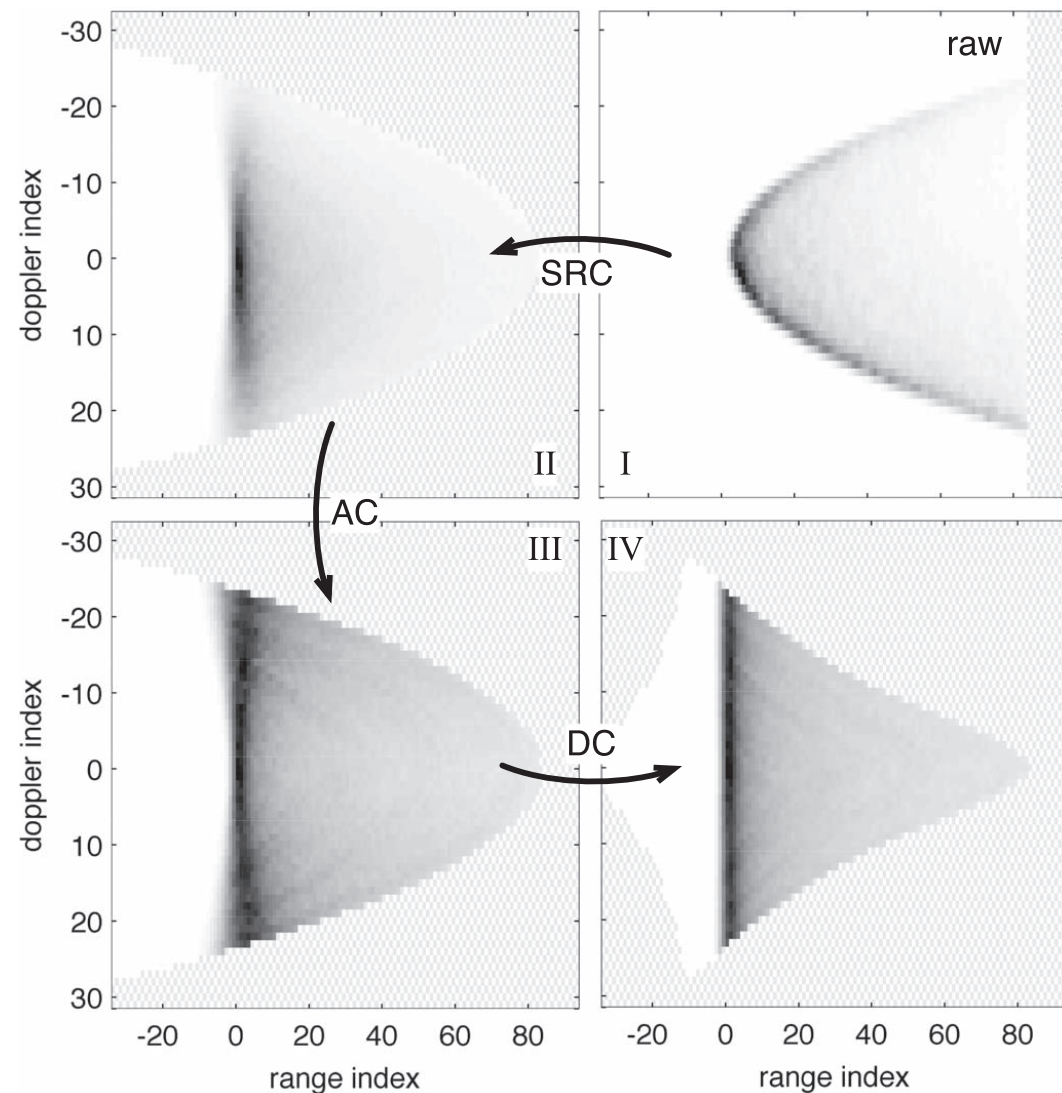
Validation in German Bight by Fenoglio et al ,

Key progress points - coastal

- reduction of fitting window (CLS)
- georeferentiation of Stack and selection of range bins for retracking (Starlab)
- both to be explored in SCOOP

Key progress points – AC/DC

- Amplitude Compensation/Dilation Compensation
- Ray et al
 - OSTST2014
 - GRSL 2015
- is it done in S-6??



Key progress points

- **Proper SAR focusing** (Egido and Smith, OSTST2015)
 - Measured along-track resolution is ~ 0.5 meters i.e. what expected theoretically,
 - focused SAR geophysical parameters noise @ 84 Hz is equivalent to the delay/Doppler noise @ 20 Hz, so for SLA noise the theoretical limit of 0.5cm at 1 Hz is in sight.
 - However the coherent and incoherent scattering components could yet not be separated due to the presence of strong reflection from the ocean.

RDSAR: done and dusted?

- At the time of the Gommenginger et al's review all processing options to generate pseudo-LRM had been identified and described
 - no clear new knowledge since then on RDSAR generation
- The question will be which option(s) to use for Jason-CS – goes well beyond SCOOP

SAR altimetry Workshop in 2015!

- La Rochelle, Monday 31 October
 - OSTST is Tuesday to Friday that week
- Chairs: F. Boy, P. Cipollini
- Expect SCOOP to feature significantly!