Validation Exercise over German Bight (Open Sea)

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The presentation is structured in the following points:

- Introduction/Heritage
- Dataset Used
- Validation Methods
- Results
- Conclusions
**SAMOSA HERITAGE**

- **SAMOSA MODEL**: Physically-based model developed by Starlab from first principles
- Analytical (by Bessel Functions) solutions to model the Delay Doppler Maps (DDM) for the full span of Doppler Frequencies
- Model depends on epoch, significant wave height, Pu, surface rms slope, and mispointing angle(s),
- The model independent variables are the Doppler Frequency and the Time Delay
- The waveforms are retracked by Bounded Least-Square Fitting Algorithm (Levenberg-Marquard)
ESRIN EOP-SER Section, for validation purposes and preparation to Sentinel-3 mission (SAR Retracker Algorithm Definition), implemented an ESRIN SAR Processor Prototype in order to Delay-Doppler process CryoSat FBR data and re-track Delay-Doppler Echoes

- SAR/SARin FBR/L1b DATA Archiving and Cataloguing
- SAR/SARin L1b & L2 Processor Prototype
- Input: CRYOSAR SAR FBR DATA
- Coding Language: MATLAB

- At L1b, Standard Delay-Doppler Processing (description on line in [https://wiki.services.eoportal.org/tiki-download_wiki_attachment.php?attId=2540](https://wiki.services.eoportal.org/tiki-download_wiki_attachment.php?attId=2540))
- At L2, Re-tracker with SAMOSA-Analytical Model using Levmar Least Square Estimator
- Output L1b → Radar Echogram
- Output L2 → SLA (W/O SSB), SSH, SWH, sigma0, wind speed
DATASET USED in the Validation
WE COMPARE ALTIMETERIC PARAMETERS (SLA, SWH, U10) IN SAR MODE (from ESRIN Processing) and IN PLRM MODE (from RADS Database) for 2011-2012 time

DATA IN OPEN OCEAN ONLY (> 10 KM FROM COAST)
PROCESSING CONFIGURATION
- A Pre-FFT Zero-Padding in range is applied in order to avoid aliasing for low-SWH conditions (Jansen’s sampling).
- A Doppler weighting (Hamming) is applied only over land and in coastal zone (Distance to land >10 km => weighting off, Distance to land <10 km => weighting on).
- Noisy Stack Looks ruled out from the multi-looking (stack thresholding).
- Multilooked waveform posted at same time tag than in CryoSat-2 Kiruna PDGS products.
SAMOSA Model generation: SAMOSA v3 (see last slide for ref)
Roll/Pitch mis-pointings (from platform) in input to retracking scheme and platform values are compensated for biases
Thermal Noise estimated a priori and fed as input in the re-tracking algorithm
SAR Multilooked Echo Model generated using the same number of looks used in generating the SAR input Waveform
Range PTR Alpha_p set to 0.513 (RADS PLRM Value)
Slope/Vertical Speed Effect Switched on
Method of regional comparison

- We compare:
  - SSH/SLA,
  - SWH,
  - WIND SPEED (U10),

- Inter-comparison of Altimetry Data:
  - C2/PLRM (extracted from RADS database) versus C2/SAR (processed in house at ESRIN) along tracks

- Co-location between RADS PLRM and ESRIN SAR measurement cannot be perfect (i.e. 1 Hz PLRM and SAR measurement not posted at same time and position)
  - Max permitted time difference is ± 0.5 second

- In-situ data:
  - SWH C2 versus in-situ SWH AWAC data (Acoustic Wave and Current Meter, FINO-3 Platform,)
  - SSH C2 versus in-situ GPS@TG at Helgoland tide gauge
RESULTS OVER OPEN SEA: Sea Level Anomaly
Validation against in situ data: SSH

SAR BIAS: 2.3 cm
SAR Diff Std: 20 cm
SAR Regression Slope: 0.97

(50 Km, 30 Minutes, 57 Points)
PLRM 1 Hz SSH noise = 2.3 cm @SWH=2m
SAR 1 Hz SSH noise = 0.89 cm @SWH=2m
RESULTS OVER OPEN SEA: Wave Height
BIAS: 3 cm Diff Std: 27 cm Regression Slope: 0.98

SAR Range PTR Coeff: 0.513 (as in RADS)

OVERLAPPED HISTOGRAM
Validation against in situ data: **SWH**

SAR BIAS: 0.5 cm
SAR Diff Std: 30 cm
SAR Regression Slope: 1.02

(50 Km, 30 Minutes, 57 Points)
PLRM 1 Hz SWH noise = 16.9 cm @SWH=2m
SAR 1 Hz SWH noise = 6.88 cm @SWH=2m
RESULTS OVER OPEN SEA: Wind Speed
Received Power Level corrected for AGC, AGC setting & PTR Gain Drift

Sigma nought calculated from \( P_u \) inverting SAR Radar Equation (i.e. now using SAR Footprint);

CryoSat sigma nought compensated for a bias (-3.5 dB) to align Envisat to CryoSat mission (Mission Inter-calibration)

Finally, Wind Speed extracted from sigma nought using the same wind model than Envisat (Abdalla’s Model)
OVERLAPPED HISTOGRAM
MAP of Wind Speed Diff. SAR vs. PLRM

Difference between RADS PLRM U10 and ESRIN SAR U10

MOST of Differences between ± 0.5 m/sec
COMPARISON AGAINST ECMWF MODEL

Bias: 0.5 m/sec
Diff Std: 1.3 m/sec
Regression Slope: 0.94
Scattering Index: 0.17
PLRM 1 Hz U10 noise = 25 cm/sec @SWH=2m
SAR 1 Hz U10 noise = 6 cm/sec @SWH=2m
Things to do

- Spectral Analysis
- Release SAR L2 Data to the community (ESA GPod Service + SandBox Concept)
- Calculation of look-up table correction (LUT) for range and SWH (to mitigate impact of squared sinc PTR’s approximation to a gaussian function)
- Minor SAMOSA SAR Echo Model Update (to improve fit with the input waveform)
- S-3 SAR Retracker DPM (v2.3.0) delivered to S-3 PAD Team (Pierre Femenias) with the configuration followed during the validation exercise
CONCLUSIONS

- **ESRIN SAR 1Hz Noise @SWH=2m:**
  - 0.89 cm for SSH
  - 6.8 cm for SWH
  - 0.077 db for Sigma nought
  - 6 cm/sec for U10

- **RADS PLRM 1Hz Noise @SWH=2m:**
  - 2.3 cm for SSH
  - 16.9 cm for SWH
  - 0.31 db for Sigma nought
  - 25 cm/sec for U10

- **SSH/SLA**
  Good consistency between SAR and PLRM (bias 1cm, std 6 cm, slope 0.97)
  Std wrt in-situ data at comparable level in SAR mode (19.8 cm) than in PLRM mode (20 cm)

- **SWH**
  Good consistency between SAR and PLRM (bias 3 cm, std 27 cm, slope 0.98)
  Std wrt in-situ data at comparable level in SAR mode (30 cm) and in PLRM mode (33 cm)

- **U10**
  Very Good consistency between SAR and PLRM (std 40 cm/sec, slope 1.00)