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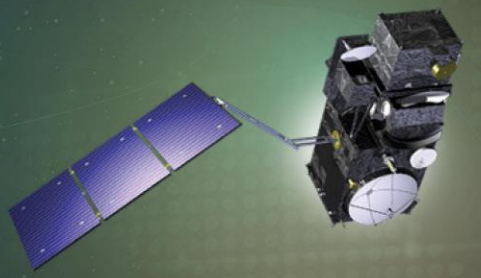

7th Sentinel-3 Validation Team Meeting 2022

18-20 October 2022 | ESA-ESRIN | Frascati (Rm), Italy

Altimetry Wrap up - Summary and Recommendations

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And the S3VT Altimetry Team

S3VT-ALT group

- ~40-45 participants to the S3VT Altimetry sessions !
- 32 Oral presentations
- 2 posters

Instruments and products quality

- Very good quality of the Sentinel-3 constellation and the instruments were shown during the S3VT#7 over all the surfaces (oceans, coasts, inland waters, sea-ice and land ice), even if further improvements can still be done…
- SRAL/MWR calibration has a normal behaviour, demonstrating the good health of S3A&B
- Drifts not present in transponders
- Extension of the ground infrastructure for Altimeter Calibration
  - Positive for multi-mission cross-comparison and long term monitoring
- Issue with ASC and DESC signal on 36 GHz channel since 2021
  - No correction applied today on 36 GHz
- New algorithms implemented in IPFs have seen significant improvements in the products
  - Specially with the release of the Land Thematic Products
  - Release of Marine BC005

Orbit products quality

- The CPOD Service continues providing orbital products to the S3 Constellation with an accuracy well below the original requirements.
- In addition, the NRT products are generated now with shorter timeliness.

- The CPOD Service is about to evolve significantly on the following areas:
  - Use of the ITRF 20 by end of November 2022.
  - Substitution of the POD SW (NAPEOS) with focusPOD, owned by GMV, in January 2023.
  - Use of the new gravity fields COST-G, in the first half of 2023, to improve the accuracy of the orbits.
  - Change the STC and perhaps also the NRT, to use Integer Ambiguity Resolution, to improve the accuracy and stability of the orbits. To be done during 2023.

Global Ocean (I)

- **Sea Level**
  - Still not enough data available to fully assess the impact of BC005 on the sea level (for climate applications)
    - There is an improvement, not possible to fully see how much the S3A SAR drift is corrected

- **Wave Height**
  - Reprocessed SAR SWH from BC005 shows good improvements
    - Very good impact when used into assimilation
    - Less benefits from PLRM wave height

- **Wind Speed**
  - Good wind speed results, consistent with other altimeters and model

- Good overall performance over ocean (Sea Level, Winds and Waves)

- Users waiting for the full mission reprocessing (BC005) for deeper analysis

Global Ocean (II)

- ✓ **Wet Tropo**
  - ✓ Good results, not drifts on S3 side

- ✓ Interesting work on Wet Troposphere correction, showing that improvements can still be done:
  - ✓ BC005 REP should include a consistent GPD+ **(REC)**
  - ✓ NN with 5p (dynamic SST from ERA5) shows very good results *(already rec from prev S3VT)*
  - ✓ Promising work with 1D retrieval for WTC

- SRAL Processing:
  - ✓ Vertical and Horizontal wave velocities need to be corrected **(REC)**
    - ✓ Reduces inconsistencies with PLRM/LR, 1 cm SSH and up to 40 cm SWH
  - ✓ Retracking
    - ✓ For Costal areas and Polar ocean (leads) fully-focused SAR shows interesting results
    - ✓ Other retrackers (no FF-SAR) also provide better results than the 'standard' ocean retrackers currently available
    - ✓ Physical Retrackers should be used to avoid discontinuities between Ocean and Polar Ocean (leads) **(REC)**

Inland Waters

- ✓ **Quality of current PDGS Land products:**
  - ❖ Quality consistent in time
  - ❖ Root mean squared error (RMSE) is generally below 20 cm over lakes
- ✓ **September 2022 OLTC update is applied (from v6.1 to v6.2 for S3A, v3.1 to v3.2 for S3B)**
  - ❖ We confirm the improvement over some targets previously degraded in the previous version
  - ❖ Few cases to investigate deeper
- ✓ **First evaluations made on Thematic Hydrology products:**
  - ❖ Retracking noise is being reduced thanks to 0-padding : from ~18cm down to ~7cm
  - ❖ Hamming windowing: across track signal emerges when not exactly at the nadir of water, beware of measurements interpretations when switching from PDGS to Thematic
- ✓ **New Fiducial Reference Measurement (FRM) will be provided to better validate the Sentinel-3 data, thanks to the St3TART project**
- ✓ **Evaluation of different level-2 retrackers dedicated to coastal and inland waters is on-going in the frame of HydroCoastal project**

Sea Ice

- ✓ **Evaluation of the new Sea Ice thematic product**
  - ❖ Great improvments thanks to Zero-Padding (and Hamming)
  - ❖ Reached a quality very similar to CryoSat-2 Ice PDGS

- ✓ **First future evolutions envisaged for Sea Ice Thematic products:**
  - ❖ Computation of Sea Ice Thickness. This will be done step by step, by first analysing the different options available for snow depth and sea ice type
  - ❖ Update of the Mean Sea Surface (eg, DTU21, CNES/CLS 2022)

✓ **Small Iceberg can be better detected with SAR mode compared to P-LRM.** Very good agreement in the iceberg detection between S3A and S3B.

✓ **Lake Ice Thickness (LIT) estimation from altimetry can be affected by ice and overlying snow.** University of Waterloo is working with snow radiative models to characterise the sensitivities on Sigma-0, Tb and waveform, in order to improve the retrieval of LIT.

Land Ice

- ✓ **Sentinel-3A and Sentinel-3B elevations were cross-compared over lake Vostok, and also compared to ICESat-2 and Icebridge.**
  - ❖ Excellent consistency between S3A and S3B
  - ❖ Median absolute Deviation between S3A and ICEsat-2 is only ~17cm
  - ❖ OCOG provides better precision compared to the UCL ice sheet retracker (~factor 2)

- ✓ **First analyses were performed to look at the seasonal variations of geophysical estimations** (most likely due to change in snow properties)

- ✓ **Evaluation of the new Land Ice thematic product:**
  - ❖ Improvement of the data coverage, especially in the ice margins (thanks to the delay-Doppler processing with extended window). ~95 % of waveforms can be considered as "good quality" over the Antarctic ice sheet, compared to ~90% with the current operational product

- ✓ **CLS presented a new relocation method, using simulation over HR DEM.** Very promising performances in terms and accuracy and precision, in particular over the ice sheet margins

S3VT#6 Recommendations status

- ✓ Ocean [Sea Level]:
  - ✓ REC-6-01: S3A SAR and PLRM range drift due to PTR shape evolution at ground segment should be corrected as soon as possible
    - ✓ REC-6-02: Range Walk correction shows to correct for a large part of the S3A SAR/PLRM range difference and should be implemented in the ground processing
    - ✓ REC-6-03: Numerical retrackers can account for PTR shape evolution and should be used in the ground processing when operationally feasible
  - ✓ REC-6-04: Further investigations need to be done in S3B drift
  - ✓ REC-6-05: LR-RMC processing over ocean to improve smaller scale observations of sea-level
  - ✓ REC-6-06: Internal tides should be used in the ocean processing
  - ✓ REC-6-07: Usage of combined MSS should be investigate in the standard products

S3VT#6 Recommendations status

- ✓ Ocean:
  - ✓ REC-6-08: Increasing the posting rate of SAR waveforms significantly reduces the noise in the estimation of geophysical parameters
- ✓ Ocean [SWH]:
  - ✓ REC-6-09: R&D activities to further improve SAR SWH, as shown by S3VT members
    - ✓ REC-6-10: Implementation of exact 0-masking in the S3 IPF to correct the SWH echo centring error
    - ✓ REC-6-11: Investigate the impact of vertical wave motion in SAR/PLRM sea-state differences
    - ✓ REC-6-12: Investigate the wave and wind bias reduction by deep learning
- ✓ Sea Level in the leads
  - ✓ REC-6-13: Improved L1/L2 processing is needed to better retrieve Sea Level in the Leads
- ✓ Coastal:
  - ✓ REC-6-14: Dedicated coastal retrackers are needed for S3 Marine products

S3VT#6 Recommendations status

- Radiometer:
  - ✓ REC-6-15: Correct for Asc/Desc signal on 28.3GHz BT
  - ✓ REC-6-16: Improve the dynamic source of SST for 5P retrieval algorithm

- Inland Water:
  - ✓ REC-6-17: Ensure Cal/Val analyses based on in-situ measurements as essential for inland water measurement accuracy assessment (Str3tART Project)
  - ✓ REC-6-18: Develop a dedicated Arctic Hydrology product including lake ice thickness
  - ✓ REC-6-19: Develop dedicated retrackers needed for S3 Inland Water processing
  - ✓ REC-6-20: Develop Fully-focused SAR processing over small water targets as promising
  - ✓ REC-6-21: Assess MNR/LND mask refinement over estuaries to ensure river/estuary continuity
  - ✓ REC-6-22: Continue improving S3A/B OLTC, including new virtual stations other than rivers, lakes and glaciers

S3VT#6 Recommendations status

- Land Ice:
  - ✓ REC-6-23: Implement improved slope correction and perform retracker improvements to narrow the gap between S3SAR and CS2SARin over the ice margins
  - ✓ REC-6-24: Implement filtering to mitigate large outliers in regions of very high slope over land ice
  - ✓ REC-6-25: Consider adding TFMRA retracker to the Thematic Land Ice IPF

- Sea Ice:
  - ✓ REC-6-26: Align S3 Land STM Sea Ice processing baseline to CryoSat-2's one
  - ✓ REC-6-27: Thematic Data Products are awaited by the user communities to continue improving the S3 Land data quality

- ✓ General:
  - ✓ REC-6-28 : Look for larger participation of Cryosphere/Hydrology communities

S3 ALT Recommendations (already present)

- REC-7- : Assess MNR/LND mask refinement over estuaries to ensure river/estuary continuity (REC-6-21)
- REC-7- : Develop Fully-focused SAR processing over small water targets as promising (REC-6-20)
- REC-7- : Continue improving S3A/B OLTC, including new virtual stations other than rivers, lakes and glaciers (REC-6-22)

S3 ALT Recommendations

- REC: Offer option to download S3 Altimetry data over user defined geographical areas
- REC: Assess ERA5 usage to understand if it brings benefits just for REP or also NTC (impacting timeliness)
- REC: Further assess and possibly correct MWR 36 Ghz asc/des differences

- REC: Investigate the usage of FF-SAR and other retracking techniques to improve retrievals in Coastal and Polar Oceans, in an operational context
- REC: removal of 'reduced_measurement.nc' from Marine products
- REC: Renaming of the internal netcdfs of SR_2_WAT___ to include pass numbers, (like S6)
- REC: BC005 REP should include a consistent GPD+
- REC: Vertical and Horizontal wave velocities need to be corrected (follow up of S3-QWG-ALT.5.3)
- REC: Investigate the provision of 5Hz SWH in NRT Marine products
- REC: Physical Retrackers should be used to avoid discontinuities between "open" Ocean and Polar Ocean (leads)

S3VT#7 Recommendations

- ✓ REC: Extension of the sea-ice thematic mask over Antarctica ice shelves, in order to anticipate for ice calving (when land ice areas become sea ice)
- ✓ REC: Extension of the Hydro – Inland Water mask to includes estuaries
- ✓ REC: MSS DTU21 or CNES/CLS 2022 to be considered for Sea Ice Thematic product
- ✓ REC: Thematic mask to be made available on Sentinel OnLine in a kml format (or shapefile?)
- ✓ REC: Improvement of the data retrieval from the ESA/EUM data hubs (geographical selection)
- ✓ REC: Clear description of the S3 Land Thematic processing to be documented (Product Handbook is coming!)

S3VT fully appreciate the recent improvements :

- New Land Thematic Products
- New Marine BC005
- Looking forward for the up-coming Full Mission Reprocessing of both S3 Marine and Land altimetry products