Toward Higher resolution Level3 altimeter products

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Motivations

Why a L3 altimeter product with a 5Hz (~1.2km) sampling ?

→ To answer the users' need & Copernicus Marine Service requirements:

- Toward higher resolution model in open ocean and coastal areas: model resolution increased by a factor 3 or more in the post 2025 period.
  - → need higher resolution altimeter products to constraint them (P-Y Le Traon, OceanPredict 2019)
- For regional applications/models
- Downstream applications: marine safety; biogeochemical activity; Research activities

→ Could be of interest for coastal areas applications (excluding littoral)

Motivations

L3 5Hz products currently processed in R&D context (CNES funding*)

V1

Regional North Atlantic.
Delivered in 2018 on AVISO+.
Objectives :

- Demonstrate the added value of the higher sampling (5Hz (~1,3 km) instead of 1Hz (~7km)

V2

Regional Europe*
Delivered in 2020 on AVISO+ & Copernicus Marine Service
Objectives:

- Better resolve the small mesoscale structures → use up-to-date geophysical corrections and innovative altimeter processing
- Fix some anomalies detected in the v1 samples, improve the processing Consolidate the design of the processing for a future operational production.

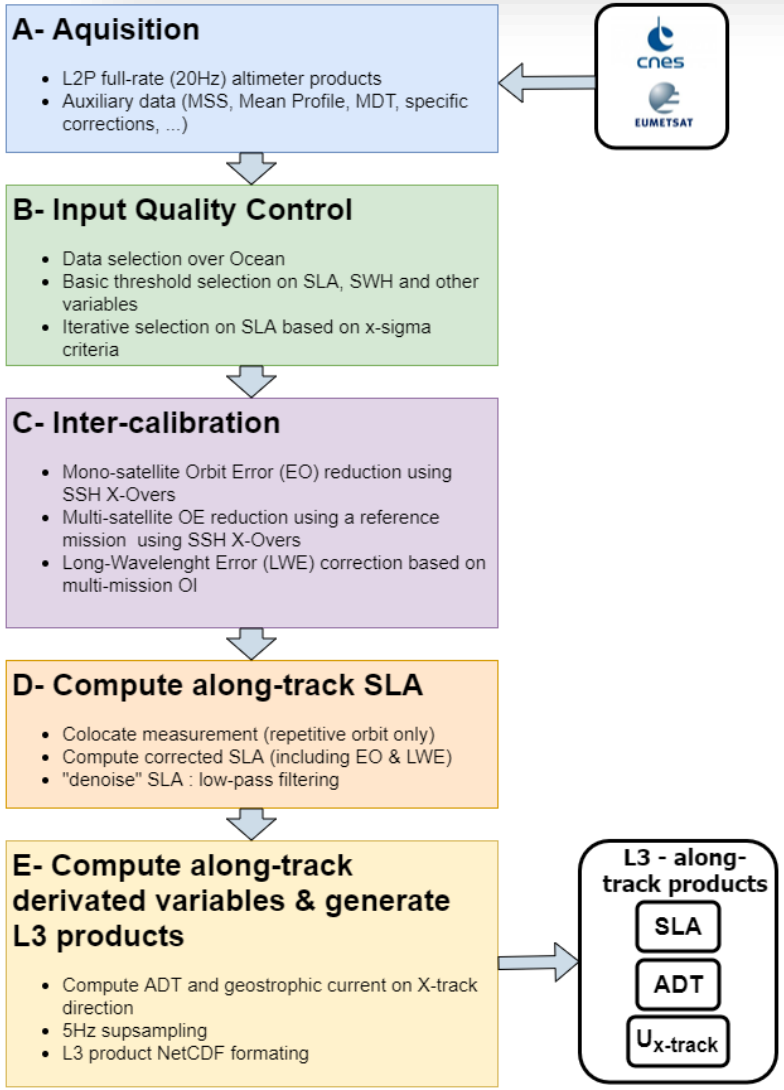
V3

Global Ocean
In preparation.
Objectives:

- Demonstration of production over the global ocean
- Improve the processing; Consolidate the design of the processing for a future operational production.

**Specific production over the Black Sea funded by ESA (EO4SIBS project)*

L3 5Hz processing overview



Nearly the same processing steps than for conventional L3 1Hz production with some adjustments:

- Upstream used with full rate resolution (20Hz) → Sea level measurement processed in 20Hz up to the end of the processing.
- Use up-to-date altimeter standards and corrections able to reduce the measurement noise (quite high on raw 20Hz measurements !)
  - SAR : LR-RMC processing (Moreau et al, 2020)
  - LRM : Adaptive processing (Thibaut et al, 2017)
  - All: up-to-date SSB (3D version when available ; Tran 2020); High Frequency Adjustment (Zaron et al, 2016; Tran et al, 2020)
- Some key parameters updated specifically on the full rate sampling when possible (MSS (or Mean profile if available), SSB, ….)
- Quality control criteria fitted on the full-rate sampling. Still under progress.
- Low-pass SLA filtering to remove short wavelength dominated by noises.
  - cut-off variable from one altimeter to the other to fit the different observing capabilities
- Geostrophic current estimation (on X-track direction) using “sla_filtered” variable as upstream
- 5Hz subsampling applied at final processing step

Samples V2

Some validation results

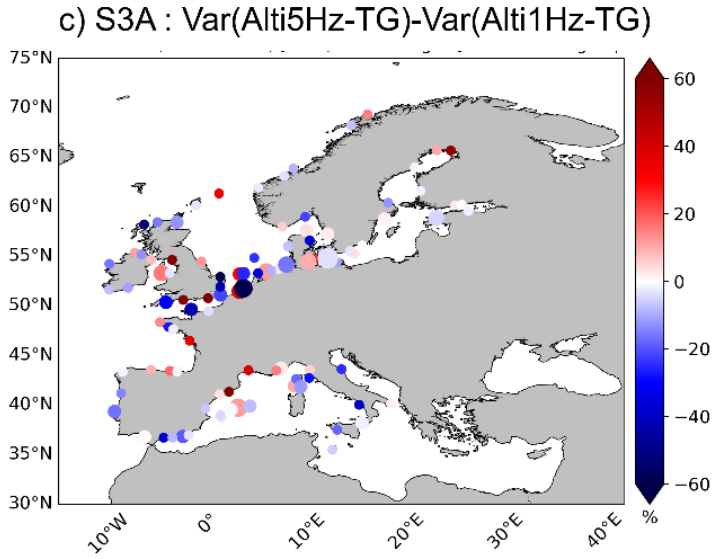
L3 5Hz are compared with L3 1Hz altimeter products :

L3 5hz Product defined close to the coasts

	L3 1Hz	L3 5Hz
S3A	10 km	5 km
J3	11 km	6 km

Mean distance of the nearest point to the coast for which the sampling rate reaches at least 80% of the maximum number of cycles defined for the period between mid-2016 to the end of 2018. Results obtained with L3 1Hz & 5Hz products, for S3A and J3.

Improved consistency with TG measurements



- Higher Alti-TG data pair to compare when L3 5Hz altimeter product is used : ~9% with S3A; ~6% with J3
- Reduction of the variance of the differences between altimetry and TG when L3 5Hz altimeter product is used : -5% with S3A; -17% with J3

Figure :
Reduction of the variance of the differences between S3A altimeter measurements and TG SLA signal when the L3 5Hz altimeter product is used rather than the L3 1Hz. (Unit: % of the variance of the TG signal).

Example of application

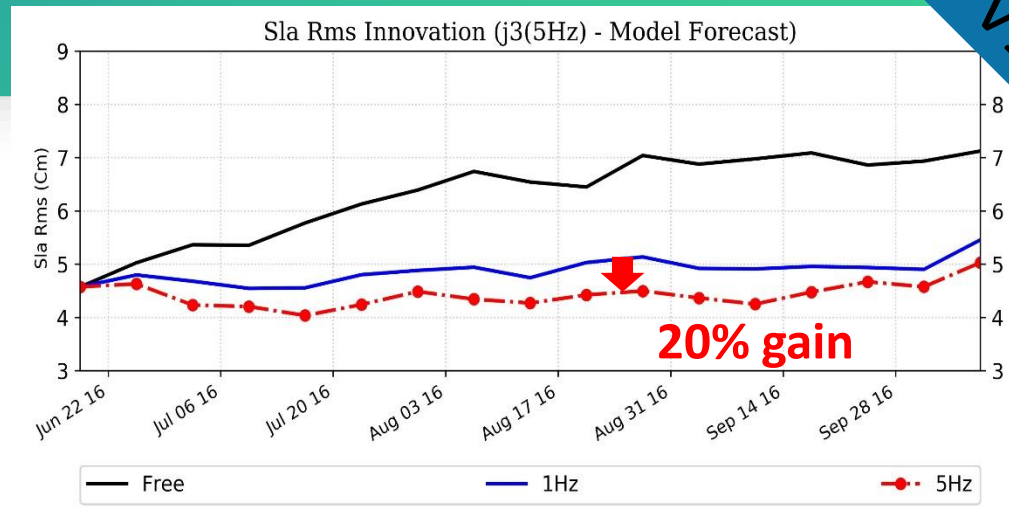
Samples V1

Courtesy of Mounir Benkiram (MOi)

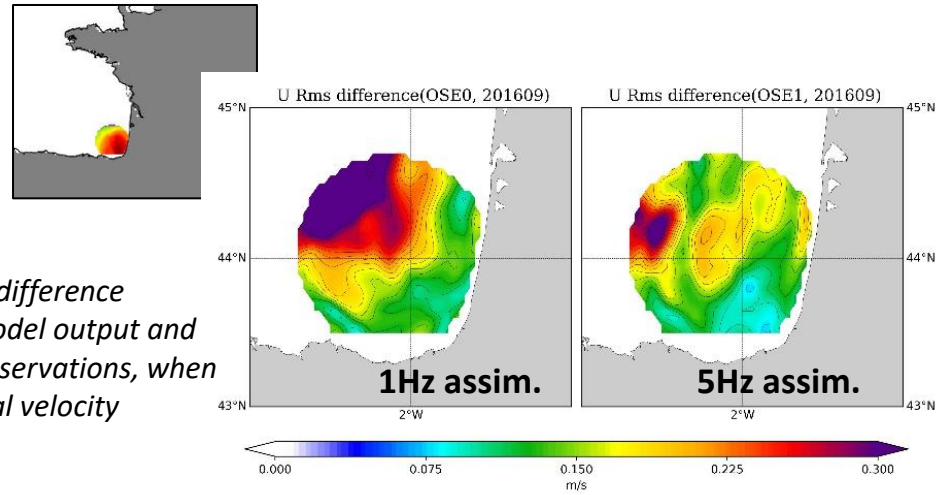
Test impact of the 5Hz altimeter products (V1 samples) assimilation into the CMEMS IBI model with 1/36° spatial resolution :

➔ the high-resolution products significantly improve the model performances:

- Higher resolution SLA assimilation impact at mesoscales → visible on SLA increments
- Model SSH forecast improved → better consistency between model forecast and observations: 20% gain
- Positive impact on other variables → modelized SST better in accordant with observations when assimilation 5Hz altimeter products rater than 1Hz
- Better consistency between model output and independent measurement



SLA innovation temporal evolution (difference between observation and model forecast) for model free run (black) and model assimilated with 1Hz (blue) or 5Hz (red) altimeter measurement



RMS of the difference between model output and HF radar observations, when model. Zonal velocity component.

Samples V2

New insight into the altimeter spectral content with Sentinel-3A

Pujol et al, In prep.

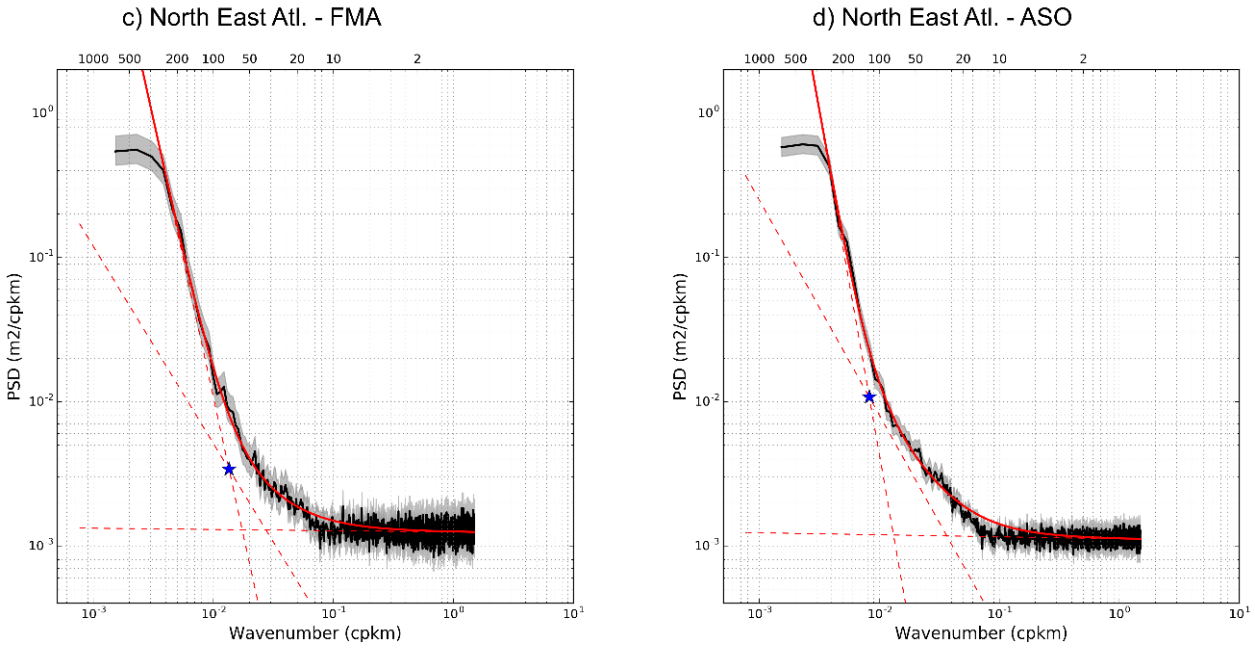


Figure :
Black line : PSD of the SLA along the S3A track in the North Atlantic domain (bottom). FMA (left) and ASO (right) 2017-2018.
Red lines: Reconstructed PSD from line characterizing the balanced/unbalanced motion and noise signal.
Blue star: transition scale (Lt) dividing balanced and unbalanced motion

Although residual errors are still present in altimeter measurements, the full rate processing allows us to quantify the contribution of the unbalanced (ageostrophic) motion at short wavelengths :

- Specific spectral slope at small wavelength (~100-30 km)
- Lt wavelength of transition between balanced & unbalanced motion assessed
- Spatial and seasonal variability consistent with previous studies (e.g. Qiu et al. 2018)

Coastal currents

EO4SIBS

Grégoire et al, ESSD, In review.

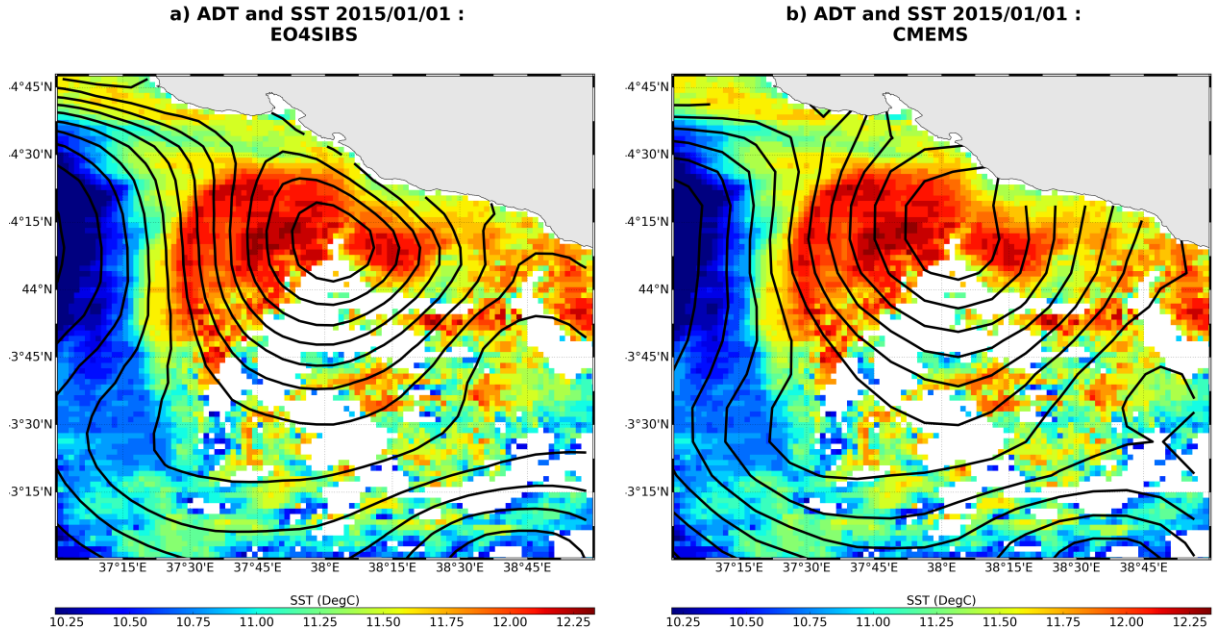


Figure :
Example of an eddy observed with EO4SIBS (using L3 5Hz & optimized mapping parameters) (a) and CMEMS (using L3 1Hz) (b) SLA gridded products for day 2015/01/01. Black lines show contours of Absolute Dynamic Topography (ADT). SST field in background show the presence of the eddy underlined by ADT contours

Case of the Black Sea :

Use L3 5Hz in upstream of mapping processing contributes to better resolve coastal eddies

Note : L3 5Hz combined with optimized mapping processing

conclusions

We are working on the development of a L3 along-track product with 5Hz (~1,2km) sampling. Samples are delivered on AVISO+:

- V1 & V2 regional version of samples already available and showing promising results
- V3 Global ocean version, including improved processing, soon available

➔ First dedicated for regional applications. Nevertheless, could also be of interest for coastal applications (> 5km near coast)→ do not hesitate to test them and give your feedback (content, quality, sampling, …): always valuable to improve the products!

Perspectives

In a near future:

➔ Work under progress :

- Methodology to deliver the raw SLA at 5Hz (“sla_unfiltered” variable)
- R&D CNES to better characterize the sea level doppler altimeter content at short wavelengths and develop corrections.

➔ **L3 5Hz operational production for Copernicus Marine Service over the Europe area foreseen in November 2022**

In the longer term:

- L3 5Hz operational production for Global ocean foreseen in Nov. 2023
- Possible evolutions of the product to better fit coastal users’ needs: integration of the corrections/processing/parameters recommended by the coastal altimetry expert community
- SWOT : use Nadir ASAP; work already on-going to define the processing for KARIN measurement

Thanks for your attention

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