Interactive comment on “DUACS DT-2018: 25 years of reprocessed sea level altimeter products” by Guillaume Taburet et al.

Anonymous Referee #1

Received and published: 18 February 2019

Authors: We acknowledge Rev. #1 for his/her review. All comments and remarks have been considered. In the next paragraphs we present the reviewer’s comments followed by our point-by-point reply (blue color).

General comments: Sorry, but I ran out of energy before finishing reading this paper. I found it to be extremely superficial, repetitive and unclear. I think it would be very difficult for altimetry beginners to understand, and too vague to be informative for experts, so I’m not sure what audience it would be useful for. So I suggest it goes back for a major rewrite, and well as addition of more information.

Authors: Considering your comments, we have tried to make the necessary modifications to improve the manuscript. However, this article is not intended to provide a course on altimetry processes for beginners but rather to present a new dataset. The structure and organization of this article was intended to be very similar to what had been done in the article dedicated to the DUACS DT2014 dataset (Pujol et al., 2016). We realized that some sections deserved important clarifications. We added them to the new version of the manuscript.

Specific comments (written as I read the paper) Abstract 1) "new altimeter standards ... has been used" 1) what are ’altimeter standards’? I think I know but many people won’t. Especially in an Abstract, please use language that people will understand. 2) change ’has’ to ’have’.

Authors: The term “altimetry standards” regroups algorithms and parameters used to estimate the different fields of the equation: SLA=orbit-range-∑correction-MSS. The notion of “altimeter standards” or “standards” is commonly used in the literature and particularly in the last two articles concerning DUACS reprocessing: Dibarboure et *al*. (2010) and Pujol et *al*. (2016). The current manuscript being closely linked to these two papers we have chosen to keep this notion. A dedicated chapter of the manuscript entitled “Altimetry standards” presents and explains in detail what these standards correspond to (section 2.2 Altimetry standards).

As recommended by the reviewer (see also comments 4) 5) and 2.2 3)) and for greater clarity, we have added details to the specific chapter « 2.2 Altimetry standards ».

Intro 1) Sentence 1: "so called" -> "called". "Exists" -> "has existed"

2) p2 line 1 focus->focusses. I think I’ll stop noting grammar edits. There are too many.

Authors: The authors have asked for an English grammar and spelling correction service in order to improve the quality of the manuscript.

3) p1 l5 "Sentinel-3 L3 products are processed on behalf of EUMETSAT". This is confusing for some readers on 2 counts: they might not know what Sentinel-3 means. You just have to say "the Sentinel-3 altimeter mission". Don’t use the passive verb "are processed", especially straight after saying that who does the work has just changed. Say who now does it.

Authors: Done.

4) "standards" see above

Authors: See above

5) line 20. "standards". That words again, but this time I start to think I don't know what is meant. "processing from the standards to L3 and L4 products". This is terminology that is common among remote sensing specialists but is unfamiliar to a large fraction of the target audience. The previous paragraph referred to two products in meaningful language. Connect back to those products now via simple names. I don't think those are L3 and L4 but I might be wrong.

Authors: The sentence has been rewritten for more clarity.

Data Processing 1) "cumulated" I don't think this is a real word. I think you mean "26 mission-years". Ie the sum of all the mission durations. This term was used before but I let it slip.

Authors: Done.

2.1 2) "complementary" this is very vague. If you are going to mention HY2A and its problems there is no point being cryptic and making people guess what you mean.

Authors: This section has been rewritten.

2.2 3) "geophysical standards". OK this is where we define what was referred to earlier as "altimeter standards and geophysical corrections". I see now why you have chosen a nice simple term like 'standard' but I'm sorry, I think it is too meaningless to be useful. I know this debate is old but I think this solution is a very bad one. New users will be confused by it. I think you need a quick little explanation explaining the equation SLA=Range-range_corrections-orbit-MSS-HF_alias_terms, noting that the terms in that equation are not really 'corrections'. The altimeter measures what it measures, which is not quite what everyone wants, for all purposes. De-tiding is not making the answer more correct. It is making it wrong if you want the tide still there. Similarly for DAC. It is only for the purpose of making gridded SLA products that all these terms are needed, so start by saying that.

Authors: See the discussion above concerning the term "altimetry standards". This section has been rewritten. In addition, a paragraph concerning specific along-track (L3) products has been added in section 2.4. It introduces the possibility to remove specific geophysical effects that are taken into account in the DUACS processing.

This article is not intended to provide a course on altimetric processes for beginners but rather to present a new dataset. The readers are advised to refer to the existing literature presenting the altimeter measurements. We have added a specific reference: Escudier, P., Couhert, A., Mercier, F., Mallet, A., Thibaut, P., Tran, N., Amarouche, L., Picard, B., Carrère, L., Dibarboure, G., Ablain, M., Richard, J., Steunou, N., Dubois, P., Rio, M. H., and Dorandeu, J.: Satellite radar altimetry: principle, geophysical correction and orbit, accuracy and precision, in: Satellite Altimetry Over Oceans and Land Surfaces, edited by: Stammer, D. and Cazenave, A., CRC Press, Taylor & Francis, Boca Raton, 2018, https://doi.org/10.1201/9781315151779 and in particular section 1.6.2 (tides, high frequency signals).

4) Table 1 columns are variable-span. Ie some entries span several columns but it is not clear which. I'm not sure all the entries are defined, either. E.g. I can imagine people wondering what a GDR-E orbit is.

Authors: The authors have used the Copernicus Publications Word template to create Table 1. However, we have made it evolve for a better readability. This new format remains to be discussed with the publisher. In the line corresponding to the orbit parameter, the GDR mention has been replaced by POE. Indeed, Geophysical Data Record (GDR) corresponds to the generic term for L2 altimeter product whereas POE (Precise Orbit Estimation) is the exact and appropriate term. The acronym DAC have also been clarified: Dynamic Atmospheric Correction.

5) "FES2014 is the last version" I think you mean 'latest' - except that's wrong I believe. FES2015?

Authors: At the time the DT2018 products were computed, FES2014 was the latest version available. This preliminary version, noted FES2014a, has been produced in 2015 based on GOT4v8ac loading tide. Then new tide loading effects have been computed using FES2014a oceanic tide. These FES2014a tide loading effects have been used to produce the final model version noted FES2014b.

2.3 1) "homogenise" this is cryptic for most readers. I think you mean that the nonJason missions are debiased, taking Jason-class missions as 'truth' (once debiased, which is another thing to explain).

Authors: «homogenise » is used page 3 line 25 as an introduction of two different processes that are described in the following sections: global and regional bias reduction to ensure mean sea level stability and cross-calibration process to minimize inter-missions' errors at crossover. For a complete description of the processes, the authors explicitly guide the reader to a much more detailed reference: Pujol et al., 2016.

2) "...expose major changes that occurred in this DT2018 version. For an advanced description of the DUACS processing, readers are advised to consult Pujol et al., 2016. Say this earlier. However, see the next comment.

Authors: This is a reminder of the approach (see. p2L1) explaining that this article focuses on improvements of the DT2018 dataset compared to the DT2014. Thus, we think that it is adapted to keep these sentences in the introduction of section 2.3 "Evolution of the DUACS processing".

2.3.1 1) lines 25-33 "the cross-calibration step...." I see no mention of a change, so maybe this text can be shortened at lot (if this document is only about changes, as above).

Authors: Done.

2.3.2 1) "The along-track generation for repetitive altimeter mission is based on the use of a mean profile (MP) (Dibarboure et al., 2011 and Pujol et al., 2016). These MPs are necessary to co-locate sea surface heights of the repetitive tracks and to retrieve a precise mean reference for the computation of sea level anomalies. The methodology used for the DT2018 MP computation is the same as in DT2014." This is a perfect example of a sentence that I see no audience for. 'Experts' know this already. Beginners won't understand it: it is too unclear. Finally, it says there is no change since DT2014, contradicting 2.3 comment 2).

Authors: There is indeed no change in methodology (this is why the two references to Pujol et *al*., 2016 & Dibarboure et *al*., in review are mentioned) but the data selection has evolved (from line 5). Thus, the authors think that it is appropriate to briefly recall the interest of mean profiles without going into details. They mention references that are relevant for the uninitiated readers. The authors added a reference that precisely details the usefulness and processing of MP (Dibarboure et *al*., in review). To facilitate the understanding, we considered appropriate to retain the short sentence "These MPs are necessary to co-locate sea surface heights of the repetitive tracks and to retrieve a precise mean reference for the computation of sea level anomalies".

2)"For non-repetitive missions (ERS-1 during its geodetic phase, Cryosat-2, Hayaing 2A, Jason-1 geodetic phase, Jason-2 geodetic phase, Saral-AltiKa geodetic phase), no MP can be estimated. The SLA is then derived along the real altimeter tracks using the gridded MSS." same comment as above. You need to either clearly explain the difference between MP and MSS, or assume it is understood.

Authors: The authors have chosen to keep the sentence to facilitate the understanding of the following paragraph about the MSS (2.3.3 L11). Nevertheless, and as suggested, we have added references (Pujol et al., 2016 and Dibarboure et al., in review) which can help the user to have access to more details.

2.3.3 lines 1-20. This is very uninformative. 'updated' and 'refined' are very uninteresting to read.

Authors: This section lacked details; we have enriched it. The words "updated" and "refined" have been deleted and replaced by more precise descriptions of the developments implemented.

2.4 lines 23-32: this is just repetition of what was said earlier in this paper. Nor is it anything new. It is well known. I'm startng to lose my patience with this paper now.

Authors: These lines are indeed redundant with the explanations given in the introduction. This has been simplified (p2 l11-19).

lines 11-13: "As a second difference, the reference used to compute the Sea Level Anomalies is a Mean Sea Surface (MSS) for all missions in the C3S products whereas a mean profile of sea surface heights is used...." Back to this issue again. Very confusing. See comment 2 on 2.3.2 above.

—to end of 2.4. As far as I can tell, this is all old information that experts don't need to be told, and beginners won't understand, the way it is described here.

Authors: According to the authors, this major difference between CMEMS and C3S products has never been addressed (and should thus not be considered as old information) and must be described to expose the specificities of the different Copernicus products.

The product dedicated to climate applications (C3S) is based on a stable number of missions (two) in the satellite constellation and has a specific processing (which is the interest of section 2.4 and particularly from line 11 to end), that follows the recommendation made within external R&D projects (such as the ESA Sea Level Climate Change Initiative project). Along-track data were not calculated with a MP but only with the MSS (and even for repetitive missions) which contributes to improve the mean sea level stability (especially for regional products). Thus, this should not be considered as "old information", since this has been implemented for the recent production of the C3S sea level products.

Section 3. 1) Results section. But I feel unready to read about results. All I have gleaned so far is that some updates have been made, with very few details given.

2) "Additional variance is observed for high variability regions in DT2018 products and is linked to the new OI parametrization." 'linked' is it? I'm getting more and more annoyed about this persistent abscence of information. Is it secret?

Authors: The wording of the sentence has been changed and details added.

3) p8 line 4-5: "At high latitude, the difference of variance is important (100cm2 to 200cm2) and is linked to the new MSS correction." It's not obvious to me how this could be true. It must be a fairly convoluted argument.

Authors: Pujol et *al*.,2018 shows the new MSS15 is more extended at high latitude than the old one. (see also figure 1 below). This allows us to compute the OI with much more precision and stability in this region. The figure 4 of Pujol et *al*.,2018 shows the difference of the variance of SLA along HY2A tracks. These differences are major at high latitude.

Figure 2 (below) shows the difference of SLA variance with DT2018 and DT2014 gridded products from the same point of view as figure 1. The difference in spatial coverage of the two MSS explains the difference in quality of the SLA grid products in this area.

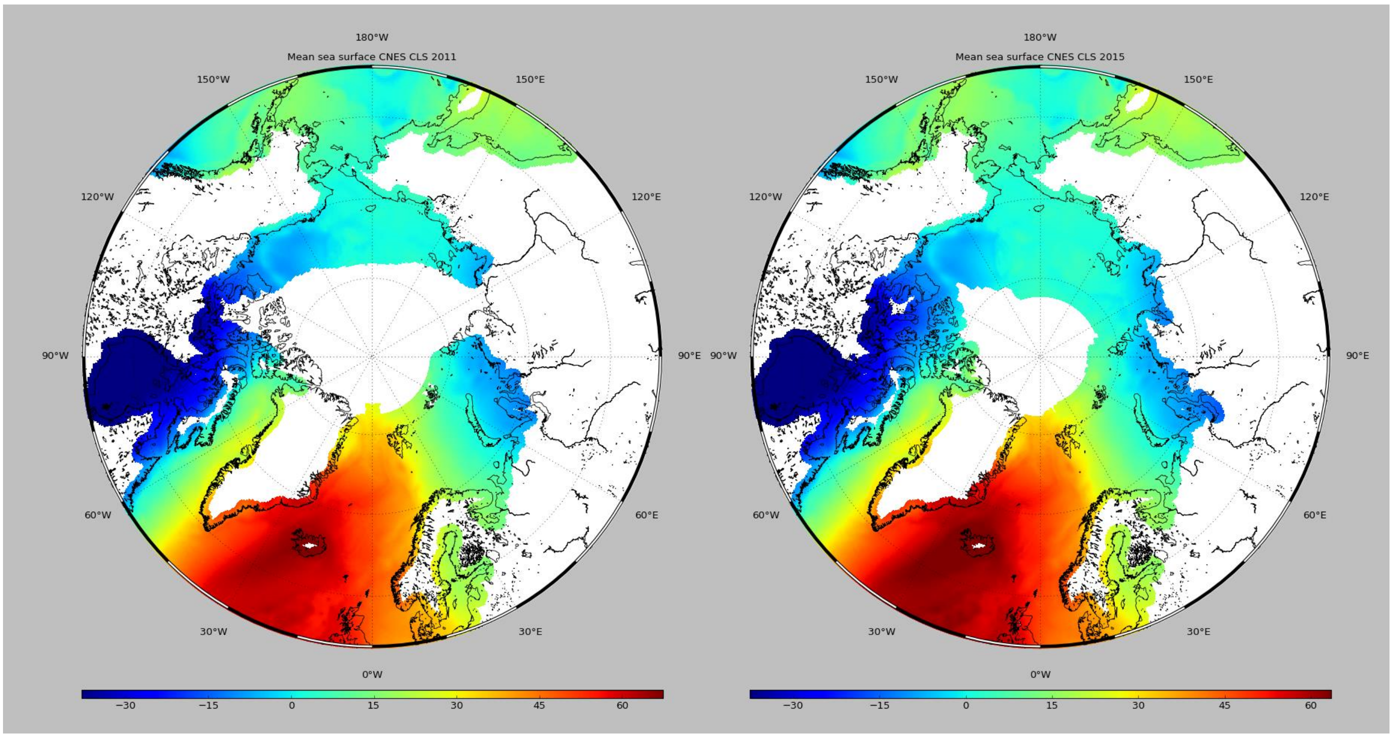

Figure 1: Mean Sea Surface CNES CLS 2011 version (left panel) and MSS CNES CLS 2015 version (right panel).

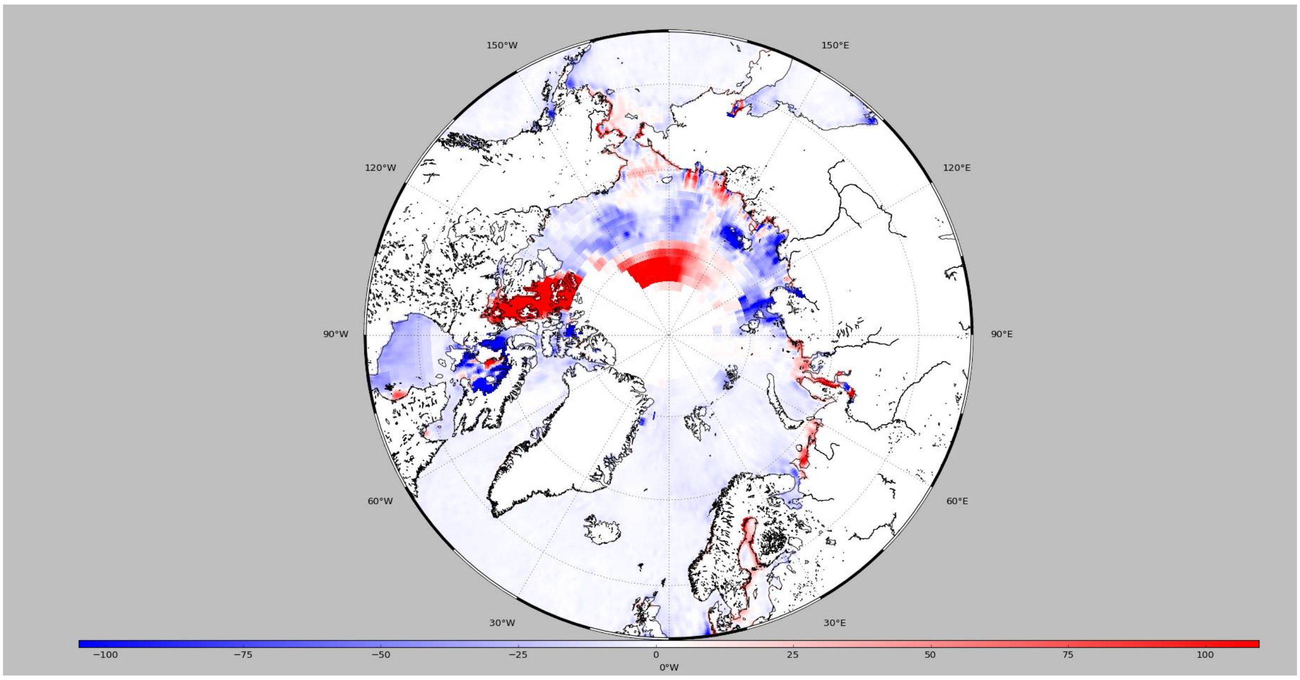

Figure 2: Difference between SLA variance observed with DT2018 and DT2014 gridded products. Same figure as figure 4 of the manuscript but centered on the North Pole. Units: cm².

4) p8 line 11-12: "However, in the equatorial band (±20◦N), the EKE in the DT2018 is less important (-17%). This is linked with the evolution of the noise measurement considered in the mapping process for all satellites." I'm getting really sick of this vague uninformative style: 'linked' and 'evolution'.

Authors: The sentence has been changed and details added.

5) p8 line 19-29: Discussion of table 3. This is an important part of this study, but lots of information is missing. Table 3 has just 2 values for each of 4 regions. Why trim it down to such a bare minimum of information? E.g. For the reference area |trackmap|ˆ2=1.4cmˆ2. This is for a 'low variability' region. But how low? Easy to answer: list the |track|ˆ2 and |map|ˆ2 values as well.

Authors: The low variability region has been introduced in Pujol et *al.,*2016. The authors found interesting to reuse it to have a reference area where observations errors are small. The SLA variability in this region is between 0 and 7 cm². This precision has been added to the Table 3. A figure (figure 5 in the new manuscript version) has been added in the manuscript to show the RMS difference (in % of RMS) between two-sat gridded products and along-track product for DT2018 and DT2014 versions.

We also added a discussion about improvements in the intertropical zone.

6) p8 line 19-29: Discussion of table 3. —-also: this is just for the 2-sat product. What about the multisat product? I hear the answer already: "Because none of the data are withheld". My response: this does not stop you listing the map minus track stats, which are then measures of the closeness of fit (as distinct from map error). To estimate map error, pick a time with many good satellites and rerun the OI, withholding one (e.g. C2) for use as the error measurer.

Authors: This issue has been discussed p8 between line 23 to 25. The error described here must be considered as the upper limit. We choose not to describe in the manuscript a configuration with more than two satellites. However, the authors also studied the period 2016-2017, and the conclusions are similar with C2 as an independent along-track mission. (using Jason-2 and AltiKa for the mapping process).

The L4 all-sat validation is complemented by *in situ* drifter's comparison.

7) p9 line 1-2 "Positions and velocities of drifters are interpolated using a 3-day lowpass filter in order to remove high-frequency motions." I have 3 grumbles: i) don't use the passive voice ('are interpolated') - it leaves it to the reader to guess who did the interpolating - we assume it was you but we can't be sure. ii) this is a very brief 'Methods' section squeezed into the Results section iii) why remove 'high frequency motions?' A 3-day filter also removes a lot of low-frequency Eulerian velocity (a drifter can easily go 1/4 of the way around a well-resolved eddy in 3 days). So, instead of filtering then differencing, it is better to do differencing then filtering.

Authors: The authors added a relevant reference which explain the interest and the method used for 3-day lowpass filtering: Use of Altimeter and Wind Data to Detect the Anomalous Loss of SVP-Type Drifter's Drogue M.-H. Rio. 2012.
The main objective of the filtering process is to discard the tide and the inertia in drifters' data.
We know that: - we don't filter enough between 10S and 10N to get rid of all the inertia
- we filter a little too much at high latitudes, knowing that we don't want to go below 24 days for the tide.
The 3-day period is a compromise between these two. The methodology still needs to be improved.

8) Fig. 6: It seems to me that 2 panels are missing: the ones showing the DT2018- DT2014 difference.

Authors: The authors have added the missing plot and related comments.

9) p9 line 4-5 "the comparison reveals that DT2018 altimetry products underestimate absolute geostrophic current." This statement is not supported by Fig. 6, Table 4, or by the mention that someone (we don't know who, because passive verb was used) has done a Taylor diagram (but kept the results to themselves - all we know is that the results are 'strong'). As in comment 5 above, list the variance of the drifter and altimetric velocities in order to prove that the altimetry under-estimates the drifter velocities.

Authors: The authors modified the sentence. It is neither an improvement nor a degradation of the products' quality but it is rather described as it is. It was also noted by Pujol et al,2016 in the DT2014 version of the sea level products.

The authors also added the RMS difference between gridded and independent drifters' measurements for DT2018 and DT2014. Related comments have been added.

10) p9 line 10-17. This discussion only talks (vaguely, but I'm not going to mention this any more because it is everywhere) about DT2018 being better DT2018, which is good news, but what people really want to know is the error:signal ratio.

Authors: The error is estimated using independent data for the SLA and geostrophic current on high variability and low variability region, coastal areas… (Table 3 to 6). The authors do not see what additional information could be added.

3.3 1) p9 line 19-33. This is all repetition.

Authors: The authors have streamlined this section.

2) p10 line 1-10. This is an interesting result that is "not understood yet". I think you could try a little harder. I see red dots (DT2018 is worse) on W and E USA, Spain (as mentioned) but also Japan - all

30-45N. Let's see some example time-series of errors for each product individually, not to mention the two signals being differenced (altim and TG) individually as well.

Authors: We know from Saraceno et al, 2018 (Estimates of sea surface height and near-surface alongshore coastal currents from combinations of altimeters and tide gauges) that coastal processes are more difficult to resolve with altimeter data, because of two types of problems. First, and most importantly, intrinsic difficulties affect the corrections applied to the altimeter data near the coast (e.g., the wet tropospheric component, high-frequency oceanographic signals, tidal corrections, etc.). Thus, data are usually flagged as unreliable within some distance of the coast. Second, the interpolation of along-track data collected by just one or two satellites provides only marginal resolution of mesoscale and smaller-scale structure in ocean circulation [Le Traon and Dibarboure, 2002; Leeuwenburgh and Stammer, 2002; Chelton and Schlax, 2003], which is dominant in the coastal region.

We did compare some time series for tide gauges on the Portuguese coast. It is difficult to draw conclusions about a particular time period over which comparisons are degraded. We were unable to correlate these degradations with periods when there are fewer data (fewer satellites in the constellation, or anomaly on a satellite).

We know that the new tide correction is particularly important in coastal areas, but again we have not been able to explain these degradations with this correction.

We are not in a position to explain the degradation observed in these well-located areas of the globe (West Coast of the USA, Portuguese coast, etc.).

3.4-onwards

Sorry, but I am not prepared to read any further. I think this paper has too many faults to be published in close to its present form.

Interactive comment on “DUACS DT-2018: 25 years of reprocessed sea level altimeter products” by Guillaume Taburet et al.

Fu Lee Lueng (Referee) lee-lueng.fu@jpl.nasa.gov

Received and published: 11 March 2019

Authors: We warmly acknowledge Lee Lueng Fu for his review. All comments and remarks have been considered. In the next paragraphs we present the reviewer’s comments followed by our point-by-point reply.

This paper presents findings from assessment of the quality of the DT-2018 products versus DT-2014. I find that the most convincing improvement is near coast and in the Med Sea and the Black Sea. The interpretation of the open ocean performance is not compelling. The following are some specific comments:

P.1 Introduction- I’d suggest adding some text on the history of altimetry missions over the past 25 years.

Authors: Done

p.2 last line- Is the data from Hayaing-2 A incorporated in DT2018?

Authors: As shown in Figure1, Hayaing-2 A data are incorporated in DT2018. The particularity of the reprocessing is to integrate additional HY2A data that were not taken into account in the DT2014 production: data from March 2016 to February 2017. This paragraph has been rewritten to be more explicit.

p.3 first line- What about the data distribution by NASA?

Authors: L2P data are only distributed by CNES and EUMETSAT. The data distribution by agencies NASA, NSOAS, ISRO, ESA, EUMETSAT, CNES… are taken into account in L2 products. DUACS processing only uses L2P data. The sentence has been reformulated in the manuscript.

Line 6- is the altimetry community represented by the OSTST? If so, please mention it.

Authors: Done

p.5 first line- cite Table 2 when the mean period (MP) is first introduced.

Authors: Done

Line 5- what is "upstream measurements"?

Authors: These “upstream measurements” correspond to the L2P products that have been presented previously. The sentence has been rewritten.

Line 17- give a reference for the MSS.

Authors: Done.

Line 18 - delete "of" after "benefit"

Authors: Done.

Line 24 - What is "Theoretical Track"?

Authors: The authors added a reference (Dibarboure et *al.*, 2011) which provide appropriate details: "Altimetry satellites generally use repetitive orbits: after 10–35 days, the sensor flies over the same locations, hence the notion of cycles (time needed to revisit the same location) and the ability to co-locate data. However, the satellite ground track cannot be perfectly controlled and is kept only in a band about 1 km wide. It is thus necessary to use an arbitrary and mission-consistent position for the co-location process. SSH measurements are then projected onto these co-location points."

p.6 line 11-give reference for the MSS

Authors: Done.

p. 7 line 16- delete "at" after "be"

Authors: Done.

line 29-30 - Is "additional variance for high variability regions in DT2018" an improvement? if so, why?

Authors: At this stage, this diagnostic is only used to characterize the impact of the new mapping process and new altimeter corrections. It is not presented as an improvement (It might as well also correspond to noisier DT2018 products). The only conclusion is that there is more variability in DT2018 products. It is only in a second step, by comparing with independent dataset and *in-situ* measurements, that we show that this gain of variability corresponds to an improvement.

p.8 line4- why is the difference of variance important? What does it mean?

Authors: The authors have reformulated this sentence.

Line 9- How is the EKE at the equator computed while geostrophy breaks down there?

Authors: The geostrophic current products disseminated to users are computed using a nine-point stencil width methodology (Arbic et al., 2012) for latitudes outside the ±5°N band. In the equatorial belt, the Lagerloef methodology (Lagerloef et al,1999) introducing a β plane approximation is used. The EKE is computed from this geostrophic estimation. This methodology did not changed since DT2014 version.

As at the equator the geostrophy breaks down, the ±5°N band is usually masked at the equator. Figure 5 has been corrected.

Line 11- What does it mean by "less important"?

Authors: The authors have reformulated this sentence.

Line 16- Given the issue of geostrophy near the equator, how would one interpret the equatorial EKE reduction as improvement?

Authors: The equatorial EKE reduction is a direct consequence of the increase of the noise measurements considered in the OI process: Observation errors have been increased in the equatorial belt, so the SLA signal is smoother and less energy is observed in this region. It has been noted that in DT2014 products, there was too much noise at the equator.

In the ±5°N band, near the equator, the EKE has been masked.

p.9 line 4- Is the fact that DT2018 products underestimate absolute geostrophic current an improvement? If not, what is the interpretation?

Authors: It is presented as a fact, not an improvement. Main reasons are that absolute geostrophic current from altimeter are smoother (fewer small scales) than with drifters, there is probably still some ageostrophic signal left in drifters' data.

line 5- The equatorial regions in Fig 6 are blocked but not in Fig 5?

Authors: The authors have corrected this mistake.

line 13 - What does it mean by "improvement is clearly visible in the intra-tropical band" while the regions are blocked in Fig 6?

Authors: The sentence has been reformulated to take into account that the ±5°N band is masked.

p.10 line7- Please quantify the global reduction of the variance.

Authors: Global reduction of the variance is around 0.6%. it has been added in the document.

line15 - What are the "three estimates"? I see only two in Fig 8 left.

Authors: The authors have reformulated the sentence. The first estimate using along-track measurements of the reference mission only (Ablain et al.,2017) is not display here.

p.11 lines 13-15- I think the information of Table 5 is sufficient and Fig 9 can be deleted. It does not convey much additional information.

Authors: The authors have replaced the figure with the difference of the root mean square of the SLA minus independent Tope/Poseidon along-track SLA, using successively DT2018 and DT2014 gridded product. The authors thought that the spatial information conveyed by this comparison would be more relevant. We have added a description of this new figure in the body of the manuscript.

Line 26- Please quantify the overall improvement shown in Fig 10.

Authors: Overall reduction of the variance for Mediterranean product is around 0.4%.

Interactive comment on “DUACS DT-2018: 25 years of reprocessed sea level altimeter products” by Guillaume Taburet et al.

Anonymous Referee #3

Received and published: 26 March 2019

Authors: We warmly acknowledge Rev.#3 for his review. All comments and remarks have been considered. In the next paragraphs we present the reviewer’s comments followed by our point-by-point reply.

General Comment :

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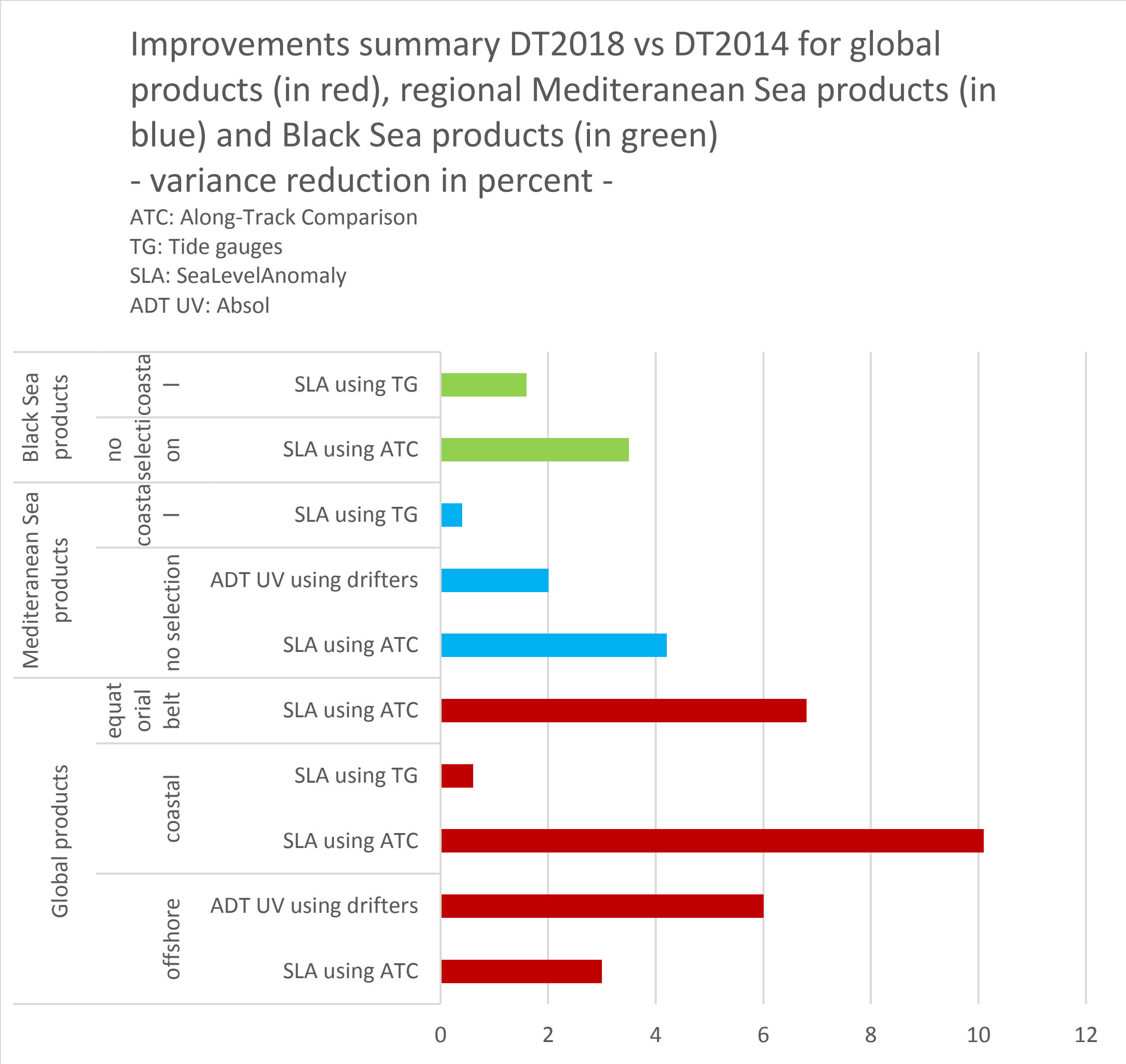
The manuscript presents the overall enhancement of gridded and along-track altimetry products following the DT2018 reprocessing, in a way that is similar to the DT2014 reassessment published earlier. Methods and Processing for quality assessment are therefore established, and skill assessment has not been developped further, but this is acceptable to me. I believe it is a necessary step to publish such reassesment peridodically, and to synthetize skill metrics for the state-of-the-art altimetry products as proposed. I therefore support the publication of this manuscript, suggesting some modifications below. Title is appropiate.

* As a suggestion : I believe the whole manuscript could be summarized on a single figure, in the form of a target or taylor diagram showing skill metrics for the different products (along-track, gridded SLA, gesotrophic currents) and scales (regional, global coastal, global offshore, climatic, etc ..) showing DT2014 postions and DT2018 positions. This is a mere suggestion, but I think it would provide a very efficient overview of the DT2018 update. Unless there are good justifications why this can not be done (at least for part of the datasets presented), I think it would be relevant for the manuscript to consider issuing this figure. Specific Comments (I start with question mark "?" to denote a suggestion)

Authors: The authors do agree that this suggestion is a good idea. We have tried to compute such figure reusing existing results, and particularly Table 3 to 5. However, the result does not appear to us to be sufficiently successful to be published. It would deserve much more substantive work. The authors keep the idea and will try to implement it in future quality document associated with the DT2018 products and for future reprocessing.



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* Abstract: P1L19 : I understand the reason for providing quantitative metrics in the abstract, but the term "errors" is too vague in the present abstract. Please precise.

Authors: The authors specified that these values have been computed using independent and *in-situ* measurements. In particular, the difference in variance of difference between altimetry and independent dataset allows to characterize this error.

* Text :

P3L5-6 :? recommendationS, correctionS

Authors: Done

P3L33: "in Deep Ocean" -> "in the deep ocean".

Authors: Done

P4L18 : It would ease the read to define "geoditic" and "drifting" mission, and help nonspecialized readers to grasp the challenges of altimetry processing.

Authors: The authors replaced the terms “geodetic” and “drifting” by “non-repetitive mission”.

P4L23 : please define more clearly the "percentage of data recovery"

Authors: The authors have reformulated this sentence which was very confusing. There was no data in DT2014 products and now validated measurements are available.

P5l20 : complete: differences of ...

Authors: Difference of SLA. It has been specified both at line 19 and 20.

P5l29 "law-pass" -> "low-pass"

Authors: Done

P6L6:7: ? consider Capet et al. 2014 that adressed those issue for DT2014.

Authors: Indeed, this sentence is incorrect/misunderstood. The authors rewrote this passage taking into account the publication Capet et al., 2014.

P6L9 : Does "selection" applies on 1) altimeter data for along-track data product generation or 2) along-track product for gridded products generation ?

Authors: it is for gridded product generation. The explanation has been clarified.

P6L14:15 vs P6L20:21 : There seems to be apparent contradictions here, please C2 rephrase for clarity (".. unchanged for global and Black Sea, wrt to DT2014" VS "BlackSea paramters are NOW similar to global, except for scales ... ".

Authors: Done

P6L27: correct "Different parameters leadS"

Authors: Done

P7L30: There is a problem in the sentence "This ... variance". Even after displacing "the", the meaning is not clear, please clarify.

Authors: Additional variance, between 2% and 5%, is observed for high variability regions in DT2018 products.

P8L4: precise the sign of the 100-200 cm2 difference of variance (but I think it’s both plus and minus).

Authors: Done.

P8L17: rephrase "less peaky"

Authors: The standard deviation of DT2018 EKE is less important than for DT2014 EKE: EKE variations are less important. This section has been improved and details have been added.

P8L22 : could you explain why only th period 2003-2004 can be considered for this assessment ?

Authors: We choose the 2003-2004 period because it is a period over which we have 4 altimeter missions available: TP, J1, EN and GFO. This allow us to keep 2 missions independent for the validation. The remaining 2-altimeter constellation used for the mapping can be compared to the altimeter constellation available before 2003 or for the C3S production. To test the relevance and robustness of the diagnosis, we varied the independent missions over the 2003-2004 period, using alternately J1, EN and GFO as independent missions. The conclusions remain the same. Moreover, it is a period that has already been studied in Pujol et al, 2016, so we thought it would be interesting to continue over this "reference" period. We also did the study on another more recent year (2017) and the conclusions are similar.

P8L23: The author avoided the nomenclature "two-sat"/"all-sat" up to this point. Can it be also avoided here ? (I think it is the only place where it is used).

Authors: Done

P9L8 : ? is it "COvariance and RMS" ?

Authors: The Taylor skill score (Taylor, 2001) is defined as: $S = \frac{4(1+R)}{\left(\frac{\sigma_{mod}}{\sigma_{obs}}+\frac{\sigma_{obs}}{\sigma_{mod}}\right)^2+(1+R_0)}$

Where R_0 is the maximum correlation attainable (hereafter $R_0 = 1$), R is the correlation coefficient between the model and the observations, σ_{mod} and σ_{obs} are respectively the model and the observations standard deviations.

So it is more correlation and standard deviation than variance and rms.

P9L10 : "altimeter maps" -> "geostrophic current maps"

Authors: Done

P9L12 : lowercase "Variance"

Authors: Done

P9L20 "points" -> "data points"

Authors: Done

P9L20/22 : rephrase "We gain all points".

Authors: Done

P9L26 "in the" repeated

Authors: Done

P10L4 : Why "maximum" correlation ? Does that refer to a selection amongst the neighboring pixels ?

Authors: The processing is detailed in Valladeau et *al.*,2012. The method is based on a criterion of maximal correlation between tide gauge time series and altimeter gridded products, where the most consistent state of the ocean between both data time series is considered within 300km around tide gauge. The main advantage of this method is to reduce the effect of oceanic variability and the error on the MSS with respect to the same altimeter point.

p10L26 : "a measurementS"

Authors: Done

P11L3, remove "." after "yr" (2x).

Authors: Done

P11L18 "For" -> "for"

Authors: Done

P11L26:28 Why is there no TG validation for the BlackSea ? Explain.

Authors: It has been added.

P12L14 "large" -> "largeR"

Authors: Done

p12l22 "lager" -> "larger"

Authors: Done

P13L8 "for" -> "from"

Authors: Done

P13L26 Biblio ref for eddy tracking, instead of html ?

Authors: The authors have added a reference to a poster presentation which was presented during OSTST 2018 : A Delepoulle et al. and the user manual that describes Mesoscale Eddy Trajectory Atlas product based on DT2018 altimetry products.

* Figures & Tables :

****

* Are appropriated and all useful in general. * Small to very small coordinates, axes and colorbar title. Please ensure readability.

Fig 1: What determines the end of the bars for the future ? scheduled lifetime ? please precise.

Authors: Nominal mission life time for missions before launch. Extended lifetime for launched missions. And end of next year for old missions (to account for possible obviated anomalies). Generally derived from CEOS (Committee on Earth Observation Satellites) timeline, or official announcements. Note that the launch dates and lifetimes are constantly in flux, so this figure periodically updated as an indicative timeline either than exact plan from Space Agencies.

Fig 2: Probably the less useful figure. If considered essential, should the figgure be reprocessed with larger bins ? It does not provides many information as for now, except : "more data in the 20km coastal band", "lot of noise in the center" and " a strange, uncommented blue track in the center of East Med". Unless justified otherwise, i suggest to remove this figure.

Authors: The authors have decided to remove this figure.

Fig 3,: caption : rephrase "Loss ones".

Authors: The authors have rephrased this sentence.

Fig 6. Second half of the caption ("Difference of the variance ... ". Does not correspond to the figure (eg. refers to negative values). -> ? missing panel ?

Authors: The missing panel has been added to the figure.

Fig 9: Caption mentions histograms that are not visible on the figure.

Authors: This caption refers to an old version of the figure. It has been corrected.

Fig 10 : use divergent colormap for the panel f,g,h (eg. blue-white-red)

Authors: The authors have changed this figure.

* References :

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* There are many references to work 'in prep.', including on to "In prep. to be submitted to OD in 2016" (Lyard et al.) . Please check with editorial office on the policy as regards reference to unpublished works.

Authors: The authors have contacted the editor. Here is the answer: In general, please note that "submitted to", "in preparation", "in review", … can be left as is. During typesetting of your manuscript our Typesetters will check all references related to Copernicus Publications for an update. If an update is available our Typesetters will insert it and inform you accordingly.

* The reference style is not homogeneous, with years being given some times at the end, some times after the authors. Please homogenize.

Authors: Done

* There are (many) reference works not provided in the bibliography (eg. Valladeau et al, 201 ; Le Traon et al, 1998, Ducet et al 2000, Le Traon & Ogor 1998 ; Le Traon et al, 2003 ; Lumpkin et al. 2013 ; Taylor, 2001 ; Watson et al, 2015 ; Beckley et al , 2017 ; Dieng et al 2017; Ballarota, in prep ; d'Ovidio 2015.)

Authors: The authors added the missing references.

* Similarly there are (many) references in the biblio that are not mentionned in the text. I do not think it is my duty to revise this for you extensively. Please check carefully.

Authors: The authors have checked. Many references in the biblio are not mentioned directly in the text but are mentioned in the table 1. The authors did not remove any references.

DUACS DT-2018: 25 years of reprocessed sea level altimetery products.

Guillaume Taburet[1], Antonio Sanchez-Roman[2], Maxime Ballarotta[1], Marie-Isabelle Pujol[1], Jean-François Legeais[1], Florent Fournier[1], Yannice Faugere[1] and Gerald Dibarboure[3]

[1]Collecte Localisation Satellites, Parc Technologique du Canal, 8-10 rue Hermès, 31520 Ramonville-Saint-Agne, France
[2]Instituto Mediterráneo de Estudios Avanzados, C/Miquel Marquès, 21 – 07190 Esporles – Illes Balears, Spain
[3]Centre National d'Etudes Spatiales, 18 avenue Edouard Belin, 31400 Toulouse, France

Correspondence to: Guillaume Taburet (gtaburet@groupcls.com)

Abstract. For more than twenty 20 years, the multi-satellite Data Unification and Altimeter Combination System (DUACS) system has been providing Near Real Time (NRT) and Delayed Time (DT) altimetryic products. These DUACS datasets rangeare ranging from along-track measurements to multi-mission maps of Sea Level Anomaly (SLA) and Absolute Dynamic Topography (ADT) maps. The DUACS DT2018 ensemble of products is the most recent and major release. For this, twenty five years of altimeter data have been reprocessed and A reprocessing of 25 years of data, namely: DUACS DT2018 are , has been carried out and is avavailable through the Copernicus Marine Environment Monitoring Service (CMEMS) and the Copernicus Climate Change Service (C3S) since April 2018.

Several changes werehave been implemented in the DT2018 processing in order to improve the product quality of the products. New altimetery standards and geophysical corrections werehas have been used, refined data selection was refined and has been implemented and Optimal Interpolation (OI) parameters werehave been reviewed for global and regional map generation.

Through this paper describes the, an extensive assessment of DT2018 has been carried outreprocessing. The error budget associated withto the DT2018 products at global and regional scales washas been refined defined and the improvements on the previous version were compared with the previous version quantified (DT2014; Pujol et al., 2016). The DT2018 mesoscale errors at mesoscaleswere estimated using independent and in-situ measurements. They and have beenare reduced by nearly 3 to 4 % for global and regional products compared to the DT2014. This reduction is even greatermuch more important in coastal areas (reduction is up to 10%) where it is directly linked to the altimeter geophysical corrections appliedused toin the DT2018 processing. The cConclusions are very similar concerning geostrophic currents, where error wasis globally reduced by around 5% and as much asup to 10% in coastal areas.

1 Introduction

Since 1992, high precision sea level measurements have been provided by satellite altimetry. They have largely contributed to better understand both the ocean circulation and the response of the Earth's system to climate change.has been able to

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~~provide high precision for mesoscale and large scale~~large-scale ~~monitoring. It has become a key indicator for climate change studies (ref CCI) and a variable of interest for scientist for data assimilation.~~ Following Topex-Poseidon in 1992, the constellation has grown from one to six satellites flying simultaneously (see Figure 1~~Figure 1figure 1Fig.ure 1~~). The combination of these ~~altimeters~~missions permits to resolve the ocean circulation both on a mesoscale and global scale and on different time scales (annual and inter-annual signals and decadal trends)~~main space and timescales of the ocean circulation in particular the mesoscale ocean circulation~~. This has been made possible thanks to the DUACS altimeter multi-mission processing system, initially developed in 1997.~~In this sense and in order , in this sense and to merge homogenous and intercalibrated altimetery missions, the multi-mission processing system for altimetry data known as the DUACS system haswas developed emerged in 1997.~~

~~The multi-mission processing system for altimetry of altimeter data so called known as DUACS (Data Unification and Altimeter Combination System) exists has existed since was developed in 1997.~~ Ever since~~Since then~~, it has been producing~~ed~~ altimetry products for the scientific community in either Near Real Time (NRT), with a delay ranging from~~of~~ a few hours to one day, or~~and~~ Delayed Time (DT), with a delay of a few months~~, altimetric products for the scientific community~~. The processing unit has been redesigned and regularly upgraded as ~~the~~ knowledge of altimetry processing has been refined (Le Traon et al., 1998; Ducet et al., 2000; Dibarboure et al., 2011; Pujol et al., 2016). Every few years, a complete reprocessing is performed through DUACS~~ll~~ that includes~~DUACS data are reprocessed including~~ all altimetry missions and that uses~~, taking into account the latest~~ up-to-date improvements and recommendations from the international altimetry community. ~~a full reprocessing is performed by DUACS including all missions and taking into account recent improvements and recommendations from the altimetry community.~~

This paper presents the latest reprocessing of DUACS DT ~~reprocessing data~~reanalysis (written hereafter DT2018) and focuses on improvements that have been ~~conducted~~ implemented since the ~~last preceding~~ version DT2014 (Pujol et al., 2016). Previously reprocessed products~~Former reprocessing~~ (including DT2014) were~~have been~~ distributed by~~through~~ Aviso from 2003 to 2017. Since May 2015, the European Copernicus Program (http://www.copernicus.eu/) has taken responsibility for all~~the whole~~ the processing, along with the operational production and distribution of along-track (level 3) and gridded (level 4) altimetry~~er~~ sea level products~~. have been taken over by the European Copernicus Program (http://www.copernicus.eu/).~~ ~~The L3 products for Sentinel-3's altimetry mission altimeter mission L3 products are processed at CLS on behalf of EUMETSAT, funded by the European Union.~~

The ~~timeseries of the~~ daily DT2018 products time series starts from January 1~~st~~, 1993 and ~~the~~ temporal extensions of the sea level record are~~is~~ regularly updated with a delay of~~nearly~~ nearly six~~6~~-months~~-delay with present day~~. Multi-mission products are based on all the altimetry satellites representing a total of 76 mission-years ~~and 20 missions~~ as shown in Figure 1~~Figure 1~~. The DT2018 reprocessing is characterized by ~~important~~ major changes in terms of ~~altimeter~~ standards and data processing compared to the DT2014 version. These ~~results~~changes~~,~~ are highlighted in section 2~~,~~ and have a significant impact on ~~the quality of the~~ sea level products quality. Two ~~different~~ types of gridded altimetery sea level products are available in ~~the~~ DT2018~~ version~~. The first~~ one~~ is dedicated to ~~the~~ retrieving~~al of~~ mesoscale signals in the context of ocean

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modeling and analysis of ~~the~~ ocean circulation on a global or regional scale. ~~This requires the most accurate sea level estimation at each time step with the best spatial sampling of the ocean by using all mission available.~~ This type of~~Such~~ dataset is produced and distributed ~~within~~ by the Copernicus Marine Service (CMEMS). The second is dedicated to ~~the~~ monitoring ~~of the~~ long-term evolution of ~~the~~ sea level, for use in both climate applications and the analysis of o~~O~~cean/c~~C~~limate indicators (such as the evolution of the global and regional Mean Sea Level (MSL~~)~~ ~~evolution~~). ~~This requires a homogeneous and stable sea level record and a steady number of two altimeters is used.~~ This second type of~~Such~~ dataset is produced and distributed ~~within~~ by the Copernicus Climate Change Service (C3S). More details on the differences between the products distributed by these two~~both~~ Copernicus Services can be found in section 2.4.

The paper is organized as follows: section 2 considers ~~the~~ DUACS processing, from the level 2 altimeter standards to the inter-mission calibration (level 3) and the mapping procedure (level 4).~~from the altimeter standards to L3 and L4 products is considered in section 2.~~ Sections 3 and 4 focus respectively on the quality of ~~the~~ global and regional products at ~~different~~ spatial (coastal, mesoscale~~s~~) and time ~~scales~~ (climate scales) scales. Finally, section 5 discusses the key results and future prospects~~perspectives are covered in section 5~~.

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2 Data processing

2.1 Altimeter constellation

The 25 ~~Seventy-six cumulated mission-years with twelve different altimeters have been used over the twenty-five~~ year~~s~~ period [1993-2017] involves~~d~~ 76 mission-years, and 12 different altimeters. The evolution of the altimeter constellation is shown in ~~Figure 1~~Figure 1. The most notable change in the constellation ~~with~~compared to DT2014 concerns availability of data from ~~the~~ Sentinel-3A and Hayaing-2A altimetry~~er~~ missions ~~availability~~. For Sentinel-3, ~~extra~~an additional six months of data (from June 2016 to December 2016) have been ~~added~~incorporated into the system. For Hayaing-2A, ~~it concerns~~ data ~~between~~from March 2016 ~~and~~to February 2017 have also been added. ~~The most notable change in the constellation with DT2014 concerns Sentinel-3A availability. Extra six months of data (from June 2016 to December 2016) have been added in the system and reprocessed. For some complementary missions, unprocessed data in DT2014 have been taken into account in the DT2018 version. For the most part, it concerns Hayaing-2A between March 2016 and February 2017.~~

2.2 Altimet~~e~~ry standards

DUACS ~~system~~ takes Level 2P (L2P) altimet~~e~~ry products as its input data. These data are disseminated by CNES~~,~~ ~~CLS~~ and EUMETSAT. L2P products are ~~powered~~supplied by L2 products that are distributed by different agencies: NASA, NSOAS, ISRO, ESA, CNES, EUMETSAT. They include the ~~geophysical~~ altimetry standard, that is algorithms and parameters used to retrieve the sea level anomalies from the altimeter measurements~~standards that allow the calculation of sea level anomalies~~, (i.e.~~(i.e.~~ instrumental, geophysical and~~,~~ environmental corrections together with~~,~~ Mean Sea Surface (~~—~~MSS)), as well as ~~and~~ a validity flag that is used to remove spurious measurements.

Indeed, the altimeteer measurement is affected by various disturbances (atmospheric, instrumental...) that must be estimated to correct it. Specific corrections are also applied to remove high frequency signal that cannot be taken into account in the DUACS processing (Escudier et al., 2017). The Dynamic Atmospheric Correction (DAC) and ocean tide correction are the two main examples. ~~–~~The DUACS DT2018 global reprocessing was an opportunity to take into account new recommendations and new corrections from the altimetry community (Ocean Surface Topography Science Team, OSTST). The altimet~~e~~ry standards ~~have been~~were carefully selected in order to be as consistent and homogeneous as possible between the ~~different~~ various missions, whatever their purpose ~~use~~ (in particular the retrieval of mesoscale signals or climate applications). This selection was~~has been~~ made possible between 2014 and 2017 in the framework of ~~the~~ phase II of ~~the~~ ESA's Sea Level Climate Change Initiative (SL_cci) project. ~~between 2014-2017. Within these~~Part of the project activities included selecting a restricted number of ~~a tight~~ altimet~~e~~ry standards ~~selection has been carried out~~ (Quartly et al., 2017; Legeais et al., 2018a). Table 1~~Table 1~~ presents the altimet~~e~~ry standards ~~that have been~~ used in ~~the~~ DT2018 and the changes ~~that occurred~~ compared with the previous version (written in bold ~~format~~). ~~Major changes from the previous version (DT2014) include the implementation of the new GDR-E orbit standard.~~ The ~~O~~orbit standards from Jason-1, Jason-2, Cryosat-2, AltiKa, Jason-3 and Sentinel-~~2~~3A altimeter missions were upgraded from ~~a GDR~~Precise Orbit Estimation (POE)~~OE~~-D to a new POE~~GDR~~-E ~~(Precise Orbit Estimation – D or E standard)~~. The n~~N~~ew ~~GDR~~POE-E standards are ~~reaching~~ of a very ~~good~~high quality (Ollivier et al., 2015; AVISO, 2017b)~~;~~. In this version, the main ~~improvement~~developments concerns~~we can note among others, the following improvement:~~ the evolutions of gravity field model that has a positive impact on regional MSL error and greatly reduce~~the important reduction of~~ geographically-correlated errors ~~that enable to improve the L2 products~~.

Various corrections ~~have been~~were updated, of which ~~and among them,~~ the new M~~ean~~ S~~ea Surface (MS~~S CNES-CLS-15~~)~~ and ocean tide model (FES2014) have led to the greatest improvements in~~of the~~ product~~'s~~ quality. Valuable~~Important~~ enhancements ~~improvements have been~~ were made in the MSS to improve performance at short wavelengths (Pujol et al., 2018a). Furthermore, ~~T~~the sea level in coastal areas and ~~in~~ the Arctic region is determined more accurately in the updated version, and errors were greatly reduced globally.~~also better retrieved and globally, a strong reduction of the errors has been carried out.~~ Concerning the ocean tide correction, FES2014 is the ~~last~~ latest version of the FES (Finite Element Solution) tide model ~~being~~ developed between~~in~~ 2014 and~~-~~ 2016. This new release ~~shows~~ gives improved results in the d~~D~~eep o~~O~~cean, at high latitudes and in shallow/coastal regions (Carrère et al., 2016 ~~and Lyard et al., 2016~~).

2.3 Developments in ~~Evolution of the~~ DUACS processing

~~The~~ DUACS processing ~~includes~~ involves an initial~~a first~~ preprocessing step during which data from the various altimeters are acquired and homogenized.~~to acquire and homogenize the data from the different altimeter. Then~~ Next, along-track products (L3) and multi-missions gridded products (L4) can be estimated. Finally, the derived products are computed and disseminated to ~~the~~ users. This section is not intended ~~does not aim~~ to ~~detail~~describe the entire data processing system in

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detail, but rather to expose the major changes made forthat occurred in this DT2018 version. For a detailed n advanced description of the DUACS processing, readers are advised to consult Pujol et al., 2016.

2.3.1 Acquisition and preprocessing

The DUACS Pprocessing sequence in DUACS can be divided into several multiple steps: acquisition, homogenization, input data quality control, multi-mission cross calibration, along-track SLA generation, multi-mission mapping and final quality control.

The acquisition and homogenization processesstage consists in retrieving altimeteerr and ancillary data and applying to them those data with the most recent corrections, models and references recommended by expert (as described in section 2.1 and 2.2). This up-to-date selection is available in Table 1Table 1.

The Input Data Quality Control is a process linked related with to the calibration/validation activities carried out for CNES, ESA and EUMETSAT. It is composed of several editing processes designed to detect and fix spurious measurements and to ensure thea long-term stability of L2P products. The up-to-date editing process is described in annual Cal/Val reports for each mission (AVISO, 2017c). Since 2014, and learning from experts' experience, great efforts have been performed made to refine this global global process and notably to adapt tailor some parts to specific regions such as: high- latitude and coastal areas. At high latitudes the idea is to filter an altimeter parameter which has a straight specific signature foron ice, compared to the ocean, and then to flag associated data as ice. But such a filtering solution is affects all datag,lobal andwith the risk that potentially disturbed compromised data outside of iecy areas can be inaccuratelybadly flagged as ice. The proposed updated evolution development consists in using a mask where so that the chosen filtering solution always provides relevant results (Ollivier et al., 2014). The mask is based on the Ssea ice concentration product offrom the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF, www.osi-saf.org) and gives us a maximum estimation of ice extent.

In coastal areas, along-track SLA measurements for non-repetitive missions were rejected for L2P DT2014 products, mainly due to a the reduced lower quality ofof the mean sea surface (MSS)MSS afolong closer than 20 km to the coast, all along-track SLA measurementr areas less closer than 20 km fromto the coast for geodetic and drifting missions were rejected for non-repetitive missions drastically rejected in the L2P DT2014 products (Pujol et al., 2016). In DT2018 benefits from a solution for , with improved quality MSS solutionquality (Pujol et al., 2018), so efforts were done made to keep retain as muchmany as possible valid measurements as possible close to near the coast. The data selection strategy is based on a median filter applied in a 30km wide strip off the coastline band from the coast (Ollivier et al., 2014). Number of valid data usable in DUACS system is now increased in a substantial proportion, especially for geodetic measurements. As a result, substantially more valid data can be used in DUACS, especially for geodetic measurements. Figure 2 presents an example of the gain of measurements for the Cryosat-2 geodetic mission in DT2018 over the Mediterranean Sea. 100% of the measurements of geodetic missions are recovered in the 20km band near the coast (all rejected in DT2014 version).

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Finally, Tthe cross-calibration step makes ensures that all data from all satellites provide consistent and accurate information (Pujol et al., 2016). Even if L2 data have been homogenized, they are not always coherent because of various geographically correlated errors ranging from instrument, processing or orbit standards. The first step ensures mMean sea level continuity between altimeter missions is ensured by reducing global and regional biases for each transition ofbetween reference missions (TP-J1, J1-J2 and J2-J3). Then, and iIn order to minimize geographically -correlated errors, two algorithms using empirical process methods are then usedapplied, namely: the Orbit Error Reduction (OER) and the Long Wavelength Error Reduction (LWER)). The OER is based on a global crossover minimization performed on mono and multi-missions crossovers (Le Traon and Ogor, 1998). The LWER is based on an optimal interpolation process and aim to remove local bias between neighboring for each satellite (Le Traon et *al.* 1998 and Ducet et *al.*, 2000).

2.3.2 Along-tTrack product generation

The along-track generation for repetitive altimeter missions is based on the use of a mean profile (MP) (Table 2, Dibarboure et al., 2011 and Pujol et al., 2016; and Dibarboure et al., in prepreview). These MPs are necessary in order to co-locate the sea surface heights of the repetitive tracks and to retrieve a precise mean reference in order to for the computeation of sea level anomalies. The methodology used to computefor the DT2018 MP computation wasis the same as infor DT2014. The . Ddifferences come arise from the upstream measurements, with as new altimetery standards were used in DT2018 (described in section 2.2), along with new data selection (see section 2.3.1) and reviewed temporal periods for the different altimeters considered. Table 2Table 2 introduces presents the altimeter missions and time periods used to compute the four different MPs that are available along the following tracks: TopexPoseidon/Jason1/OSTM-Jason2/Jason3, TopexPoseidon Interleaved Phase/Jason1 Interleaved/Jason2 Interleaved, ERS-1/ERS-2/Envisat/Saral-AltiKa and Geosat Follow On tracks.

UnlikeCompared toFollowing the previous MPs version of the MP, additional measurements collected by OSTM/Jason-2 and SARAL/AltiKa between 2012 and 2015 were usedexploited for DT2018. They concern OSTM/Jason-2 and SARAL/AltiKa. Since March 2015, however, AltiKa has been considered as a drifting non-repetitive mission for Delayed-Time products. As a resultTherefore, no we do not take into account any measurements after that date were taken into accoundt when to computinge the ERS-1/ERS-2/EN/AL MP. beyond that date. To limit the error of ionospheric correction error inover the ERS-1/ERS-2/EN/AL mMean pProfilethis MP, no ERS-2 data collected from between January 2000 andto October 2002 have not beenwere used to compute the MP because. Indeed, during this period, the ionospheric activity was much more intense during this period than between 1995 toand 2000.

New DT2018 MPs wereare defined as close to the coast as possible as illustrated in Figure 3 Figure 2. This improvement is associated with the use of the new MSS (Pujol et al.,2018a) and ocean Ttide correction and the refined selection of valid data selection (see Ssections 2.2 and 2.3.1). It has a direct and positive impact on the along -track product generation that provides will benefit of an extended coastal coverage. Globally, the comparisons of the difference at mono-mission and multi-mission at crossovers provides good results in this new version. . CCompared to the DT2014 version, we observe at

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~~global scale~~ a decrease in~~of~~ the mean of the difference at crossovers by around 0.3cm globally and up to 1cm locally (data not shown here).

It should be noted that for the Sentinel-3A, it was impossible to estimate ~~mission the estimation of~~ a precise MP ~~was not possible~~ for this reprocessing, due to the short time period (i.e. a few months) available to compute it. Consequently, data from the Sentinel-3A mission were~~are~~ only interpolated i~~o~~nto theoretical positions ~~Theorical Track~~ (Dibarboure et al., 2011), then ~~and~~ the gridded MSS (Pujol et al, 2018) ~~is~~was removed. Since the reprocessing~~then~~, an MP has been ~~evaluated~~ calculated (Dibarboure et al., in ~~pre~~prev.; ~~and~~ Pujol et al., 2018b) and the Sentinel-3A dataset ~~will~~ has been reprocessed in a ~~future~~ CMEMS version in 2019.

For non-repetitive missions (ERS-1 during its geodetic phase, Cryosat-2, Hayaing-2A, both Jason-1 and Jason-2 in their geodetic phase, ~~Jason-2 geodetic phase,~~and SARAL~~aral~~-AltiKa in its geodetic phase), no MP can be estimated. The SLA is ~~then~~in this case derived along the ~~real~~ real altimeter tracks using the gridded MSS (Pujol et al., 2016; ~~and~~ Dibarboure et al., in ~~pre~~prev).

The final~~Last~~ step of ~~the~~ along-track processing consists of~~in~~ noise reduction using ~~by~~ lo~~a~~w-pass Lanczos filtering~~,~~ and subsampling. This process remains unchanged ~~compared to~~from the DT2014 version (Pujol et al., 2016).

DT2018 ~~R~~reprocessing was also the opportunity to propose new products. New along-track products were tailored for assimilation purposes ~~and~~to ~~-~~provide users with the specific geophysical corrections, used to compute the sea level anomaly in the DUACS processing~~;~~: DAC, ocean tide and LWER. As explained in section 2.2, these geophysical effects are taken into account in DUACS because their temporal variability is too high to be resolved by altimeter measurements and to be mapped using the OI method.

2.3.3 Gridded product generation: multi-mission mapping

The multi-mission mapping proce~~ss~~dures in DUACS is based on an optimal interpolation (OI) technique derived from LeTraon et al., 1998; Ducet et al., 2000 and LeTraon et al., 2003. This method ~~aims~~ is designed~~at~~ to generate ~~producing~~ regularly gridded products ~~of~~for Sea Level Anomalies by combining measurements from different altimeters. The main objective in the DT2018 reprocessing framework was to improve gridded altimetry products ~~improvements were focused mainly i~~in the tropics, in coastal areas and at mesoscale. To do so,

~~The last reprocessing DT2014, have shown great improvement on the SLA signal reconstruction mainly offshore (Pujol et al., 2016). The reprocessing DT2018 focused on what had been less emphasized on the previous reprocessing: coastal scale and mesoscale~~, to do so ~~e. Specific parameters in the DT2018~~ OI ~~processing~~ parameters were~~have been~~ ~~optimized~~ adjusted~~to this effect~~.

The sea level ~~variability of the signal's~~ spatial and temporal variability ~~scales of the signal have~~were ~~been~~ ~~updated~~more accurately defined based~~,~~ on the 25 years of ~~available~~ observations available. ~~PA~~ ~~p~~Particular attention was~~has been~~ paid ~~put~~

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toon coastal areas, where spurious peaks of high variability were able to behave been reduced. An optimized selection of along-track data was incorporated into OI processing by changing

T the size of the suboptimal interpolation window, decreasing it by one third -decreased by 33% in regions of high variability region and in the equatorial bandbelt. .

OI Oobservation errors were increased in the equatorial bandbelt, as– the impact of filtering and subsampling had been previouslyhad beenwere underestimated in this area whichere they generates noise at small scales oin gridded products.

An optimized selection of the data has been implemented in DT2018 products. The impact is visible at different scales (mesoscale, coastal and climate scale) and over global and regional products. The observations errors have been refined. Errors induced generated when using the gridded MSS werehave been updated with the use of the new MSS versionupdated replaced with the new one for missions that do not use a precise MP (Pujol et al., 2018a). In addition, the *a priori* knowledge of the signal variance has been updated based on the 25 years of available observations.

Correlation scales were onlyremain unchanged for the global and Black Sea products, compared with the ones used in DT2014. They have been reviewed only for the regional Mediterranean products. While set to a constant values (100 km and 10 days) in the DT2014 version, a specific effort has been made to compute precise covariance and propagation models werehave been computed tofor thise DT2018 regional mapping. Spatial scales now range from 75 km to 200 km whileand temporal scales remain atare set to 10 days. These changes have actively contributed to the improvingimprovement the retrieval of the mesoscale signals' retrieval in the Mediterranean regional products (see section 4).

For the Black Sea processing, OI parameters are now similar to the global ones parameters used for the global ocean processing, except for the correlation scales which are still set to 100km and 10days.

2.4 Different products for different applications

Two different types of altimeter sea level gridded altimetry products are available in the DT2018 version. The first ontypee, produced and distributed within within the Copernicus Marine Service (CMEMS), is dedicated to the mesoscale observation. The other onetype, produced and distributed withinwithin the Copernicus Climate Change Service (C3S), is rather dedicated to the monitoring of the long-term evolution of the sea level for use in climate applications and forthe analyzingsis of oOcean/cClimate indicators (such as the global and regional MSL evolution). Two types of altimeter processing configurations are exploited to build these two products.Different processing parameters are used to generate leads to these two products. The first difference of configuration is related to the number of altimeters used in the satellite constellation.

The mMesoscale observation requires the most accurate sea level estimation at each time step, along with the best spatial sampling of the ocean. All available altimeters are thus included in the CMEMS products, and the sampling can vary with time depending on the constellation status. At the oppositeOn the other handIn contrast, the temporal stability of the surface sampling is more important when monitoringrather required for the long-term sea level evolution observation. A steady number (two) of altimeters (two) are thus used in the C3S products. This corresponds to the minimum number of satellites required to for the retrieveal of mesoscale signals in delayed time conditions (Pascual et al., 2006; and Dibarboure et al., 2011). Within the production process, the long-term stability and large-scale changes are built established onupon the records basis of records from the reference missions (TOPEX-Poseidon, Jason-1, Jason-2 and Jason-3) used in both CMEMS and C3S products. The Any additional missions (e.g. up to 5as many as five additional missions in 2017) are then homogenized with respect to the reference missions and contribute help to improve the sampling of mesoscale process samplinges, provideing the high-latitude coverage and increaseing the product accuracy. However, the total number of satellites hasstrongly greatly variesd during over the altimetry era and some biases may appear develop whenwith the introduction of a new satellite flying on a drifting orbit is introduced., Each addition, which may affect the stability of the global and regional MSL from by several millimeters (data not shown here). AlthoughEven if the spatial sampling is reduced with when there are fewer satellites, the risk of introducing such anomalyies is thus also reduced in the C3S products, resulting in and the stability is improved stability. In the CMEMS products, the stability is ensured by the calibration with the reference missions and the mesoscale errors are reduced due to the improved ocean surface sampling thanks to made possible by using the use of all the satellites available in the constellation.

As a second difference of configuration, the reference used to compute the Sea Level Anomalies for C3S products was is a Mean Sea Surface (MSS) for all missions in the C3S products whereas for CMEMS products, a mean profileMP of sea surface heights is was used along the theoretical track of the satellites following with a repetitive orbit (see section 2.3.2) in the CMEMS products. The use of MP increases the local accuracy of the sea level estimation (Pujol et *al*., 2018a and Dibarboure et *al*., in prep) but fFor the C3S productions, a non-repetitive mission (Cryosat-2) has beenwas used for a short period of time. Considering the regional mean sea level temporal evolutionUnfortunately, the combined use of MSS and MPMPmean profile for successive missions in the merged product give rise to regionalcan be at the origin of c centimetric bias when these products arefor regional products (data not shown here). SoConsequently, the systematic use of the MSS for all missions has been privileged in the C3S products to ensure contributes helpsto ensuringe the MSL stability in the C3S products; and and the use of MPmean profiles for repetitive missions has been selected in the CMEMS products to increase their accuracy of the CMEMS products is increased with by usingthe use of the mean profiles for repetitive missions.

The Ddifferences between CMEMS and C3S product quality are discussed aton a climateic scale in section 3.4.

3 DT2018 Global products quality

This sectione following chapter focuses on the quality of gridded (L4) products. We analyzedS sea surface heights and derived currents derived products were analyzed at different spatial at different scales (open ocean, mesoscale and coastal areas), distinguishing different temporal scales (from mesoscale to climatic scales). DT2018 L4 products have beenwere compared with those of DT2014 during over the time period 1993-2017 time period. Except when explicitly it is mentioned otherwise explicitly, the results presented in this section are valid for all DUACS DT2018 products distributed viain both Copernicus services.

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3.1 Mesoscale signals in ~~A~~along-~~T~~track and gridded products

Optimizing the~~The~~ mapping process ~~optimization~~ (section 2.3.3) and incorporating the new altimetery corrections (section 2.2) ha~~ve~~d a direct impact on the observation of ocean sea level and surface circulation dynamics~~physical content observed~~ in the gridded products. To characterize this impact, the difference between DT2014 and DT2018 temporal variability is ~~presented~~ shown in ~~Figure 4~~Figure 3. An ~~A~~additional variance of between 2% and 5% is observed for high variability regions in DT2018 products~~ and is linked to the new OI parametrization~~. ~~This represents between 2 to 5% of DT2018 the variance.~~ This increase is ~~mainly~~ due to having changed the OI~~the new variaibility of~~ spatial and temporal scales ~~of the signal~~ used in the mapping process and~~+~~ decreased~~ of the size of~~ suboptimal interpolation window size. The OI selection window ~~,~~is more focused on closed observations (both spatial and temporal)~~ -> more var of the signal.~~ ~~O~~In coastal areas, a~~n important~~ substantial reduction in SLA~~of the~~ variance~~ of the SLA~~ is observed~~; this is~~ due~~being related~~ to both the FES2014 tidal correction ~~FES2014~~ and, ~~in~~to a more limited extent~~ t,o~~ the new MSS~~Mean Sea Surface~~. For the tid~~e~~al correction, ~~Lyard et al.,2016 and~~ Carrere et al., (2016) have shown a reduction ~~of~~in SLA variance at nearshore crossovers~~ nearshore~~. Pujol et al., ~~(~~(2018a)~~)~~ have ~~underlined~~ emphasized that the new gridded MSS shows less~~a reduced degradation of~~ SLA degradation near the coast. These improved standards contribute to a valuable~~important~~ local reduction ~~of~~in~~ the~~ SLA ~~error~~ variance (up to 50% alongshore). At high latitudes, the difference of variance is ~~important~~ significant (±100cm² to ±200cm²~~), and~~) and is ~~linked~~ due to the new MSS correction. Indeed, Pujol et al., ~~(~~(2018a)~~)~~ have shown that the CNES_CLS 2015 MSS improves both coverage in the A~~a~~rctic and resolution of the shortest wavelengths at high latitudes.

Compared to ~~the~~ DT2014, the new version reveals~~has~~ more intense ~~geostrophic currents in~~ western boundary currents (geostrophic part). This has a direct impact on the Eddy Kinetic Energy (EKE) derived from these products. ~~Figure 5~~ Figure 4 presents the spatial difference in~~of~~ the mean EKE over global ocean between DT2018 and DT2014 products, along with ~~products and also~~ their temporal evolution. As observed before ~~in~~for the differences of SLA variance, ~~we clearly see~~ a higher energy is evident in high variability areas. This ~~represents~~ corresponds to a 2% increase in EKE in DT2018. However, in the equatorial ~~band~~ belt (±20°N), the EKE in ~~the~~ DT2018 is lower~~less important~~ (-17%). This is a direct consequence of the noise measurement that is taken into consideration in the mapping process for all satellites: observation errors ~~increased~~prescribed during OI in the tropical belt have been increased, so the SLA signal is smoother and less energy is observed in this region. ~~This is linked with the evolution of the noise measurement considered in the mapping process for all satellites. The consistency between altimeter geostrophic current and independent measurements is significantly improved in this area as discussed in section 3.2.~~ I~~O~~n coastal areas, ~~the~~ DT2018 ~~version~~ version presents ~~less~~ fewer spurious peaks of high EKE (Figure 4~~Figure 4~~ b). As already stated, this is ~~linked~~ related to ~~with~~ the improved altimetri~~c~~y correction and lower ~~the variance~~ SLA ~~reduction~~variance. Considering the mean EKE time series, a global reduction of 26 cm² (17%) is observed for dataset~~ the~~ DT2018~~ dataset~~. ~~It~~This is directly ~~linked~~ due to the lower~~with the~~ ~~equatorial~~ tropical EKE~~ reduction~~. Another~~What is also~~ important point to note is that the standard deviation of EKE~~the temporal evolution of the EKE~~ in these

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products is lower~~ess peaky~~ than in DT2014. This illustrates that EKE variations are less important, there ~~is~~are fewer isolated anomalies (and these are mostly coastal) in the new DT2018 products.

The gridded SLA accuracy ~~of the gridded SLA~~ was~~is~~ estimated by comparison~~ng SLA~~ with independent along-track measurements. Maps produced by merging only two altimeters ~~(C3S products) are~~were compared with SLAs measured along~~-~~-track from the tracks of another mission that was kept independent ~~o~~from~~f~~ the mapping process (see Pujol et al., 2016 for full methodology).~~-~~ Topex-Poseidon~~TP~~ interleaved ~~is~~was compared with gridded products that merge~~d~~s Jason-1 and E~~N~~nvisat over~~ the year~~ 2003-2004. It ~~is therefore then important to note~~must be pointed out that these results are much more representative of ~~“two-sat-merged”~~ gridded products combining two altimetry missions. P~~The “all-sat-merged” p~~roducts combining all available missions can usually benefit from ~~an~~ improved sampling when three to six altimeters are used. T~~hus, t~~he errors described here should thus be considered ~~as~~ the upper limit. Table 3~~Table 3~~ summarizes the results of ~~the~~ comparisons over different areas. Figure 5 shows the percentage of the difference in variance between gridded products and TP independent along-track measurements for DT2018 and DT2014 products. ~~-~~The gridded product error for mesoscale wavelengths ranges between 1.4 cm² (for a low variability area) and 37.7 cm² (for a high variability region). The improvements in ~~of~~ DT2018 compared with DT2014 ~~is~~affect all areas~~ global~~.~~:~~ Offshore, the improvement is ~~quite~~ fairly low (around 3%) and is associated with the enhanced version of the OI mapping parameter~~ of the OI~~. In coastal areas, the improvements are more significant (around 10%) and ~~linked related~~caused by~~ to with the use of~~ the new ~~Tide~~ tidal correction (FES2014) and, to a lesser extent, ~~with~~ to the MSS and MPs. In the tropical belt, improvements are also significant (around 9%) and related to the observation errors that were increased in this area for the OI processing.

3.2 Geostrophic current quality

~~DT2018 a~~Absolute geostrophic currents for DT2018 were~~ has been~~ assessed using drifter data for the~~ time period~~ 1993-2017 time period. The AOML (Atlantic Oceanographic & Meteorological Laboratory) database ~~has been~~was used for the comparison (Lumpkin et al. 2013). These in-situ data ~~are~~ were corrected f~~rom~~or Ekman drift (Rio et al., 2011) and~~but also from~~ wind if a drifter's~~'~~ drogue ha~~d~~s been lost (Rio et *al.*, 2012) so as to be compar~~ed~~able with the altimetry absolute geostrophic currents. Drifters ~~The p~~Positions and velocities ~~of drifters are~~were interpolated using a 3-day low-pass filter in order to remove high-frequency motions (Rio et al., 2011). The a~~A~~bsolute geostrophic currents derived from altimetry products ~~are~~ were then interpolated onto drifter positions for comparison.

The distribution of the current's intensity shows an overall underestimation of ~~current~~magnitude in altimetry products compared to drifter observations (data not shown).

~~As the previous version (Pujol et *al.*, 2016), the comparison reveals that DT2018 altimetry products underestimate absolute geostrophic current. Figure 6~~Figure 6 shows the RMS difference between the DT2018 geostrophic current and that of drifters. The m~~M~~ean RMS is nearly 10 cm/s and the main errors are located nearshore and in high variability region with peaks higher than 20 cm/s. Taylor skill scores (Taylor, 2001) were~~have been~~ computed for the zonal and meridional components of the current in DT2018. This assessment ~~lookenables~~took ~~-~~into consideration both the signal's ~~variance~~

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correlation and its standard deviation~~RMS of the signal~~. Results are quite ~~strong~~robust: 0.89 for the zonal and 0.87 for the meridional component.

~~The~~ Table 4~~Table 4~~ summarizes the mean ~~rms~~ RMS of the differences between geostrophic current maps ~~altimeter maps~~ and drifter measurements over different areas for ~~the~~ versions DT2018 and DT2014 ~~version~~. DT2018 products are more consistent with drifter measurements than ~~the~~ DT2014 version products. The improvement is clearly visible in the intra-tropical ~~band~~belt. The v~~V~~ariance of the differences with drifters is reduced around ~~by 7%~~ 20 to 40% in this area. Additional noise-like signal~~s,~~ pre~~sent~~~~viously introduced~~ in the DT2014 version ~~a~~had reduced ~~nd leading to a degradation of the~~ consistency with drifter measurement (Pujol et al., 201~~4~~6). This degradation was ~~is now~~ corrected for~~in the~~ by ~~DT2018 version. This is directly linked to~~ the change in~~of the~~ mapping parameters used for this updated version (~~see~~ section 2.3.3). A ~~S~~significant improvement can~~is~~ also be observed in coastal areas, where ~~with a reduction of~~ the variance of ~~the~~ differences with drifter measurements is reduced by~~reaching~~ nearly 15% (Table 4). Elsewhere, this reduction in the~~e~~ variance of difference ~~reduction~~ ranges ~~between~~ from 4 ~~and~~ to 7%.

3.3 Coastal areas

As described in sections 2.3.1 and 2.3.2 the new DUACS DT2018 processing has a key~~an important~~ impact on coastal areas~~.~~ ~~The clearest impact is the major gain of points from every non-repetitive missions and missions not having a MP. We gain all points no further than 20 km of the coast for these six missions over 16 years in total. There is also an improvement for repetitive missions since in average we gain points nearshore (Figure 3).~~ and ~~O~~overall, all missions have more measurements available in DT2018 compared to ~~the previous~~DT2014 ~~version~~.

~~Specific efforts were done in the DT2018 processing to improve the products quality near the coast. Choice of up-to-date standards, specifically ocean tide and MSS (see section 2.2), clearly contribute to the quality of the altimeter measurement near the coast. Additionally, refined data selection (see section 2.3.1) significantly increase the data availability in the in the band 20km close to the coast. Finally, review of the mapping parameters (section 2.3.3) also contribute to the improved quality of the gridded products in the coastal area.~~

~~Previous comparisons between gridded maps and independent measurement underlined the positive impact of the DT2018 processing in the coastal area. Compared with results obtained with DT2014 version, we observe with DT2018 a reduction of the variance of the differences between gridded SLA products and independent along-track measurements by nearly 10% (Table 3, Section 3.1), and a reduction of the RMS of the differences between altimeter geostrophic current and drifter measurement by nearly 15% (Table 4, section 3.2).~~

The assessment of ~~the~~ gridded products in coastal areas included~~was completed with~~ a comparison with tide-gauge~~s~~ (TG) measurements. We ~~have~~ used mean monthly ~~mean~~ TG measurements from the PSMSL network (Permanent Service for Mean Sea Level, PSMSL, 2016) from 1993 to 2017. We ~~considered~~ used only long-term monitoring stations with a lifetime of more~~greater~~ than two~~2~~ years. Sea surface h~~H~~eight measured by TG ~~is~~was compared with gridded SLA by considering the maximum correlation with the nearest neighboring pixel (Valladeau et al., 2012; ~~and~~ AVISO, 2017a). In ~~Figure 7,~~ Figure 7

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the variance of the difference between DT2018 altimetr~~ic~~y products and TG measurements is compared with that obtained from the differences using DT2014 altimetr~~ic~~y products. ~~-~~The results show a global reduction in~~of~~ the variance (0.6%) when DT2018 data are used. There is a clear improvement along the Indian coast, Oceania and northern Europe. ~~A l~~Local degradation can be observed along the coast of Spain and along the United States' West~~ern~~ coast ~~of United States~~. These degradations, which ~~that~~ are not observed in other diagnoses such as~~like~~ independent along track measurement~~s~~s still need to be further investigated~~are not~~ yet ~~understood yet.~~.

3.4 Climate scales

The global mean sea level (GMSL) is a key indicator of climate change since it reflects both the amount of heat added in the ocean and the land ice melt coming mainly from Antarctic and Greenland ice sheets and glaciers. Three different altimeter products can be used to compute three GMSL estimates: ~~and can be computed from t~~the time series of the box-averaged along-track measurements of ~~the~~ the reference missions only (Ablain et al., 2017), ~~. The global MSL can also be derived from the DUACS~~ L4 merged gridded sea level products from CMEMS and C3S ~~distributed by both marine and climate Copernicus services~~ (e. ~~-~~g. ~~Figure 8~~Figure 8, left). ~~Considering~~ For the same product~~s~~ version~~s~~ and computation period~~s of computation~~, these three GMSL estimates ~~(box-averaged mono-mission and two gridded products) of the global MSL~~ are considered to be equivalent since almost the same altimet~~e~~ry standards are used to compute ~~the~~ sea level anomalies and ~~for all products~~, the long-term stability for all products is ensured by using the same reference missions. The remaining ~~observed global~~ GMSL differences observed (~0.17mm/year) are not significant given the uncertainty ~~considered~~ on different scales (uncertainty in the GMSL trend is ~~approximately of~~ 0.~~5~~ 4 mm/y~~r.~~ear at the 90% confidence level given by ~~Legeais et al., 2018b~~Ablain et al. 2019). Note that as aforementioned (section 2.4), differences can be found between the two different Copernicus gridded products (CMEMS/C3S) when computing regionally-averaged MSLs~~the situation is not the same on a regional scale where differences can be found according~~ depending on~~to~~ ~~the product used (CMEMS/C3S) for the MSL computation~~.

When computing area-averaged MSL time series, users are advised that ~~the~~ DUACS products are not corrected for the effect of ~~the~~ Glacial Isostatic Adjustment (GIA) due to ~~the~~ post glacial rebound. A ~~and a~~ GIA model should be used to estimate the associated sea level trends.

In addition, between 1993 and 1998, ~~the global~~G~~-~~MSL is~~has been~~ known to have been ~~be~~ affected by ~~an~~ instrumental drift in the TOPEX-A measurement, ~~s which has been~~ as quantified by several studies (~~Watson et al., 2015~~Watson et al., 2015; ~~Beckley et al., 2017~~Beckley et al., 2017; Dieng et al., 2017). The ~~altimeter~~ sea level altimetry community agrees that it is necessary to correct the TOPEX-A record for ~~the~~ instrumental drift to improve ~~the~~ accuracy and reduce ~~the~~ uncertainty in~~of~~ the total sea level record. However, there is not ~~yet~~ consensus so far on the best approach to estimate ~~the~~ drift correction at global and regional scales. ~~The~~ DUACS ~~altimeter~~ sea level altimetry products are not corrected for ~~the~~ TOPEX-A drift, ~~waiting~~ pending~~for the~~ on-going TOPEX reprocessing by CNES and NASA/JPL but ~~the~~ users can apply their own

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correction. Adjusting for this TOPEX-A anomaly create a GMSL acceleration of 0.10mmyr^{-2} for the 1993–2017 time span that does not otherwise appear ~~otherwise~~ (WCRP 2018).

~~Figure 8~~Figure 8 (left) shows the ~~global Mean Sea Level~~GMSL's temporal evolution and associated trend computed with the new DT2018 and former DT2014 versions of ~~the~~ DUACS C3S products. ~~With~~ In the latest version, the global mean sea level trend is of 3.3 mm/yea~~r.~~r (including ~~a~~ GIA correction of -0.3 mm/yea~~r.~~r). T~~ and t~~he origin of the associated uncertainty is discussed by Legeais et al., ~~(~~2018b~~)~~. The map of the differences ~~of~~for the local MSL trend derived from the latest and previous product~~s~~ versions (~~Figure 8~~Figure 8, right) displays a pattern predominantly associated with the differen~~ce~~t ~~of~~ orbit standards used in the two ~~b~~ product~~oth~~ versions ~~of the products~~ (GDR-E versus GDR-D, see Table 1~~Table 1~~). Such a result is confirmed by ~~the~~ compari~~son~~ng ~~of the~~ altimet~~e~~ry products with the independent ~~measurements of~~ dynamic height ~~s~~ measurements derived from in-situ Argo profiles (Valladeau et al., 2012; Legeais et al., 2016).

4 DT2018 ~~R~~regional product quality

4.1 SLA field quality

As previously discussed for ~~the G~~global ocean products, the quality of ~~the~~ regional gridded SLA products is estimated ~~by~~through comparison with independent altimeter along-track and tide gauge measurements.

~~The Figure 9~~Figure 9 shows the spatial distribution of the RMS of the differences between regional DT2018 SLA gridded products and independent along-track measurements (Topex/Poseidon ~~i~~Interleaved along~~-~~ track measurements over the ~~period [~~2003-2004~~]~~ period). The ~~M~~main statistics ~~on~~for these comparisons, as well as a comparison with the previous DT2014 version, are also given in Table 5~~Table 5~~. In contrast with~~Contrary to~~ the ~~processing applied for G~~global products assessment, the evaluation of regional products cannot include the mesoscale signal analysis: the short length of ~~the main part of~~ the tracks segments available over ~~these~~ the regional ~~S~~seas does not allow ~~us to~~ accurate~~ly~~ filtering of the signal in order to focus specifically on mesoscale ~~signals~~. The results obtained show that ~~f~~For the DT2018 Mediterranean product, the main errors are located ~~o~~in coastal areas and in the Adriatic and Aegean Seas, with RMS values ranging from 6 to 9 cm. The Black Sea products ~~present~~ also show higher errors ~~o~~in coastal areas (results not shown here). The mean ~~rms~~ Variance of the differences between gridded products and along-track measurements is ~~reaches~~ nearly 17 cm² and ~~(~~23 cm²~~)~~ over the Mediterranean Sea~~.~~ and the ~~(~~ Black~~)~~ Sea. This value is higher than the mean error observed over low variability areas in the ~~G~~global ocean (Table 3~~Table 3~~), mainly due to the different wavelengths addressed in these comparisons. Compared to the previous regional ~~version~~ DT2014 version, the error is reduced by 4.2% ~~(3.5%)~~ for the Mediterranean Sea and 3.5% for the ~~(~~Black~~)~~ Sea. It is important to note that these results are representative ~~of the quality~~ of ~~the~~ gridded product~~s~~ quality when only two altimeters are available. These products can be considered to be~~as~~ degraded products for mesoscale mapping since they use minimal altimeter sampling.

Compared to the previous version, c~~C~~onsistency with monthly TG~~Tide Gauges~~ measurements (~~Figure 10~~Figure 10) is improved locally ~~with~~ in the regional DT2018 Mediterranean gridded product ~~from the Balearic to Ligurian Seas as well as~~

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in the Adriatic Seain the western part of the Mediterranean basin. compared to the previous version. In some other coastal areas, dDegradation is however observed, however, in some other coastal areas, especially in the center of the basin and along the Turkish coast the Aegean Sea and along the Sicilian coast. For the Black Sea gridded product, only nine Tide Gauges were available for the comparison. With the exception of a tide gauge at the eastern end of the Black Sea, on the Georgian coast, these DT2018 regional products are improved of the order of 1 %. (à mettre à jour avec nouvelle figure- sans le point en mer de marmara).

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4.2 Geostrophic current quality in the Mediterranean Sea

DT2018 regional absolute geostrophic current in the Mediterranean basin has beenwas assessed using drifter data for the period [1993-2017] period. The data were collected from dDrifters released in the Mediterranean Sea as part ofin the frame of AlborEx (Pascual et, al., 2017) and MEDESS-GIB (EU MED Program; http://www.medess4ms.eu/ ; Sotillo et al., 2016) multi-platform experiments as well as other experiments gathered incorporated into CMEMS the In Situ Thematic Centre (INS TAC) products from CMEMS were used. These data are The processeding similarly of these data is analogue to that applied to the global product (see section 3.2).

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Table 6Table 6 summarizes the main statistical results for the whole basin. The DT2018 regional product presents a correlation coefficient with drifter data 4% larger greater than that obtained when using the DT2014 regional product. Moreover, the errors in the former later version are slightly reduce lowerby 1%, whilst its improvement in the explained variance reaches is as high as 14%.

We repeated tThe analysis was then repeated but for the different dynamical sub-regions of the basin (see Figure 11Figure 11.a) reported by Manca et *al.* (2004). This differentiation is based on the typical permanent features in the upper 200 m of the water column. Overall, comparisons between geostrophic velocities derived from the DT2018 regional product and absolute surface velocities retrieved by the drifters (Figure 11Figure 11. b – e) present reveal a correlation coefficient larger greater than 0.40 in most of the boxes. Correlations larger greater than 0.50 are mainly located in the southernmost part of the basin where a stronger mesoscale activity occurs; namely the Alboran Sea (DS1), the Algerian Basin (DS3 and DS4), the Sardinian Channel (DI1), the Sicily Strait of Sicily (DI3), the Ionian Sea (boxes DJ7, DJ8 and DJ5), and the Cretan passage (DH3). The overall RMS difference between both datasets ranges between 8 and– 11 cm/s, although whilst it reaches 20 cm/s in DS1 due this area'sto the strong dynamics of this area. Slightly larger errors are obtained when comparing the DT2014 product with drifter observations (figure not shown here). Furthermore, drifter data collected in boxes DS1, DS3, and DS4 present have the largest variability due to the aforementioned mesoscale activity. This fact is also reflected in the two altimetry products, which present havethere the largest variance values in the Mediterranean basin.

Overall, the correlation coefficient between the DT2018 regional product and in-situ drifter data is improvesd by between 5-10% with respect to that obtained when using the DT2014 product (Figure 11Figure 11.g). Here, positive values denote an improvement ofin DT2018 over DT2014. This fact is mainly observed in areas of strong mesoscale activity. Moreover, the errors (Figure 11Figure 11.f) are reduced around by 2% in the northernmost part of the western part of the Mediterranean

~~basin~~ basin and Adriatic Sea. However, negative values lower than 2% (slightly larger errors when using DT2018) are observed in the Algerian Basin and most of the eastern part of the Mediterranean basin. The main improvement in~~of~~ DT2018 with respect to DT2014 lies i~~o~~n the variance explained (Figure 11~~Figure 11~~.h), which presents values nearly 20%~~, (10%) larger~~ higher in the ~~former~~ later product in some ~~places~~ areas of the western, part of the~~(eastern)~~ basin and nearly 10% higher in the eastern part. This is due to ~~a~~ better captur~~e~~ing~~ of the~~ mesoscale activity. This improvement is not observed in the northernmost part of the basin, where less~~a lower~~ mesoscale activity occurs.

5 Discussions and Conclusions

More than 25 years of Level-3 and Level-4 altimet~~e~~ry products ~~have been~~were reprocessed and delivered as ~~the~~version DT2018~~ version~~. This reprocessing takes into account the most up-to-date altimet~~e~~ry corrections and also includes changes in the ~~parameters involved in the~~ mapping processing parameters. These changes impact ~~the~~ SLA signals at multiple temporal and spatial scales.

A notable~~ important~~ change concerns the gridded ~~altimeter~~ sea level altimetry products that are available in ~~the~~ version DT2018~~ version~~. They are produced and distributed through two different Copernicus Services that correspond to different applications. ~~Through~~ CMEMS distributes~~,~~ maps that includ~~ede~~ all the available altimeter missions~~ available are distributed~~. These maps~~y~~ provide~~ give~~ the most accurate sea level estimation with the best spatial and temporal sampling of the ocean at all times. Through C3S, maps that include only two satellites are used to compute the most homogeneous and stable sea level record ~~though~~ over time and space. Sea l~~L~~evel C3S products are dedicated to ~~the~~ monitoring ~~of the~~ long-term sea level evolution ~~of the sea level~~ for climate applications and ~~the~~ analyzing~~sis of O~~ocean/c~~C~~limate indicators (such as ~~the~~ global and regional MSL evolution).

Other changes were~~have been~~ implemented in~~ the~~ DT2018 processing~~;~~: the altimet~~e~~ry standards and geophysical corrections were brought~~ are~~ up-to-date with expert recommendations, and mapping parameters, ~~have been refined~~ including spatial and temporal correlation scale and measurement~~s~~ errors were refined. We also focused on ~~the~~ improving~~ement of~~ coastal editing to ~~gain~~ obtain many relevant sea level data, mainly f~~o~~rom drifting altimeters. Additional sea level data ~~have been~~were incorporated into~~ used compared to the~~ DT201~~4~~8, ~~especially~~ in particular Sentinel-3A measurements ~~that~~ taken~~have been used~~ over a 6-month extension~~ded~~ period.

~~Having discussed~~~~Dissussing~~Discussing these ~~important~~ key changes, we ~~have~~ then focused on ~~the~~ describing~~ption~~ their~~ of the~~ impact on gridded sea level products. ~~The~~ SLA variability has ~~been~~ increased in energetic areas (from 5 to 10%) and ~~reduced~~ decreased locally along ~~the~~ coasts (up to 50%). A 10% EKE decrease in the equatorial belt~~and~~ has~~ is~~ also been observed and ~~linked~~ related to the ~~refined~~ reduced measurement~~s~~ errors prescribed for OI in th~~is~~ise area.

To ~~realize~~ achieve independent comparisons,~~ we have used unrelated *in-situ* measurements. G~~ geostrophic currents ~~have been~~were examined~~d and are still underestimated compared~~ to ~~the~~ in-situ observations.~~ Nevertheless, c~~ Compared to the version DT2014~~ version~~, offshore improvements (+4-5%) particularly in the tropics (+5-10%) and coastal improvements

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(+10%) have been ~~shown~~ demonstrated using independent drifters~~'~~ data. An ~~I~~independent along-track sea level comparison and ~~T~~tide ~~G~~gauge~~s~~ comparisons have strengthened these conclusions.

Regional products are also ~~improved~~ enhanced with DT2018, taking advantage of ~~the altimeter~~ new standards and processing. The SLA gridded product errors in the regional products ~~are~~ have decreas~~ed~~ing by ~~from~~ 3% to 4% when estimated using independent along-track measurements.

The ~~l~~Limitations exposed by Pujol et al. (2016) are still valid and the errors observed in ~~the~~ retrievingal ~~of~~ mesoscale features also highlight the L4 product's spatial resolution capability. To estimate the spatial resolution of ~~the~~ gridded products, an~~an~~ evaluation was~~has been carried out~~ done based on a spectral coherence approach. A full description of this approach can be found in Ballarotta et al.~~,~~ (~~in prep.~~2019).

Many ~~products~~ applications are derived from these global and regional gridded products and ~~are strongly~~ greatly benefit from ~~affected byaffected by the~~ the products~~ir~~ quality: the Lagrangian products (FSLE d'Ovidio et al. 2015)~~, or~~ and eddy tracking application (Delepoulle et al., 2018) are ~~a~~ prominent examples.

Medium~~-t~~-term developments concern new Level-3 products that will be dedicated to data assimilation and the CMEMS Monitoring Forecasting Centre. ~~These new products will be new in Delayed-Time mode.~~ The Mean Dynamic Topography will also be updated, and the Black Sea area will be integrated. Finally, a new regional European ~~regional~~ product will substitute ~~to~~ the current Mediterranean and Black Sea products.

In the coming years, DUACS will face ~~important~~ major challenges with the arrival of new altimeter missions. SWOT, for example, will observe fine-scale dynamics~~,~~ with swath SSH observations (Morrow et al., 2018)~~,~~ that will need to be integrated into ~~the~~ DUACS ~~system~~. ~~To do so, the~~The next step, therefore, will consist in moving towards a higher resolution for along~~-~~track and gridded products. New mapping techniques should also be taken into consideration and are currently being studied such as dynamical advection (Rogé al., 2017, Ubelmann et al., 2016).

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6 Data availability

~~The d~~Datasets are available from the CMEMS web-portal (http://marine.copernicus.eu/services-portfolio/access-to-products/) and the C3S data store (https://cds.climate.copernicus.eu Level 2P (L2P) altimetry products are disseminated by CNES and EUMETSAT. L2P products are supplied by L2 products that are distributed by different agencies: NASA, NSOAS, ISRO, ESA, CNES, EUMETSAT.)~~. Level 2 (GDR) input data are provided by CNES, ESA, EUMETSAT and NASA.~~

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The L3 products for Sentinel-3's altimetry mission are processed at CLS on behalf of EUMETSAT, funded by the European Union.

The MEDESS-GIB dataset is available through the PANGAEA (Data Publisher for Earth and En~~-~~vironmental Science) repository, with the following DOI~~doi~~:10.1594/PANGAEA.853701. The AlborEx dataset is available at the SOCIB web page (http://www.socib.eu).

7 Acknowledgements

The DT2018 reprocessing exercise has beenwas supported by the CNES/SALP project and the, CMEMS and C3S services funded by the European Union. Global L3 Sentinel-3 production is coordinated by EUMETSAT and funded by the European Union.

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Table 1: Altimeter standards used in DT2018. ~~Standard c~~Changes with the DT2014 solution are underlined in bold format.

	J3	J2	J1	TP	ERS-1	ERS-2	EN	GFO	C2	AL	H2A	S3A
Orbit	POE-E	**POE-E**		**GFSC STD15 until cycle 365, STD12 afterwards**	Reaper [Rudenko et al., 2012]		POE-D	GSFC	**POE-E**		**POE-D**	POE-E
Sea State Bias	Non-Parametric SSB [Tran et al., 2012]		**SSB issued from GDR-E**	Non-parametric SSB [Tran et al., 2010]	BM3 [Gaspar et al., 1994]	Non-parametric [Mertz et al., 2005]	**Non-Parametric SSB [Tran et al., 2012]**	Non-Parametric SSB [Tran et al., 2010]	Non-Parametric SSB from J1 with unbiased sigma0.	**Non-Parametric SSB [Tran et al., 2012]**	**Non-Parametric SSB from J1**	Non-Parametric SSB [Tran et al., 2012]
Ionopheric	Filtered dual-frequency altimeter range measurements [Guibbaud et al., 2015]	**Filtered dual-frequency altimeter range measurements [Guibbaud et al., 2015]**	Filtered dual-frequency altimeter range measurements [Guibbaud et al., 2015]		Reaper NIC09 model [Scharroo et al., 2010]	**Cycle<37 Reaper NIC09 model [Scharroo et al., 2010] Cycle>36 GIM [Ijima et al., 1999]**	Dual-frequency altimeter range measurement [Guibbaud et al., 2015] (6≤cycles≤64)/GIM [Ijima et al., 1999] Corrected for 8mm bias (c≥65)	GIM [Ijima et al., 1999]		**GIM [Ijima et al., 1999]**		Filtered dual-frequency altimeter range measurements [Guibbaud et al., 2015]
Wet troposphere	From J3-AMR radiometer	**Neural Network correction [Keihm et al. 1995]**	**JMR issued from GDR-E**	**GNSS derived Path Delay [Fernandes et al., 2015]**			**Neural Network correction (5 entries) [Obligis et al., 2009 and Picard et al., 2015]**	From GFO radiometer	From ECMWF model	**Neural Network ~~correction~~ (correction ~~(~~5 entries) [Obligis et al., 2009 and Picard et al., 2015]**	**From ECMWF model**	From S3A-AMR radiometer
Dry troposphere	Model based on ECMWF Gaussian grids		Model based on ECMWF rectangular grids	Model based on ERA-INTERIM			Model based on ECMWF Gaussian grids	Model based on ECMWF rectangular grids	Model based on ECMWF Gaussian grids	**Model based on ECMWF Gaussian grids**		Model based on ECMWF Gaussian grids
Dynamic Atmospheric Correction~~AC~~	MOG2D High frequencies forced with analysed ECMWF pressure and wind field [Carrere et al., 2003; operational version used, current version is 3.2.0] + inverse barometer Low frequencies			MOG2D High frequencies forced with analysed ERA-INTERIM pressure and wind field + inverse barometer Low frequencies			MOG2D High frequencies forced with analysed ECMWF pressure and wind field [Carrere et al., 2003; operational version used, current version is 3.2.0] + inverse barometer Low frequencies			**MOG2D High frequencies forced with analysed ECMWF pressure and wind field [Carrere et al., 2003; operational version used, current version is 3.2.0] + inverse barometer Low frequencies**		MOG2D High frequencies forced with analysed ECMWF pressure and wind field [Carrere et

					al., 2003; operational version used, current version is 3.2.0] + inverse barometer Low frequencies
Ocean tide	**FES2014 [Carrere et al., 201~~5~~6]**				
Pole tide	**[Desai et al., 2015]**				
Solid earth tide	Elastic response to tidal potential [Cartwright and Tayler, 1971], [Cartwright and Edden, 1973]				
Mean Sea Surface	**CNES-CLS-2015 [Pujol et al., 2018a]**				

Table 2: Time periods and cCycles used to compute Mean Profile in the DT2018 version.

	Satellite used in Mean Profile computation	Periods used in Mean Profile computation	Cycles
Topex/Poseidon – Jason-1 – Jason-2 – Jason-3	Topex/Poseidon	January 1993 – April 2002 (9 years)	11 – 353
	Jason-1	April 2002 – October 2008 (6 years)	10 – 249
	OSTM/Jason-2	October 2008 – December 2015 (7 years)	10 – 273
Ers-1 – Ers-2 – Envisat - AltiKa	Ers-2	Mai 1995 – January 2000 (5 years)	1 – 49
	Envisat	October 2002 – October 2010 (8 years)	10 – 94
	AltiKa	March 2013 – March 2015 (2 years)	1 – 22
Topex/Poseidon Interleaved orbit – Jason-1 Interlevead orbit – Jason-2 Interlevead orbit	Topex/Poseidon Interleaved orbit	September 2002 – October 2005 (3 years)	368 – 481
	Jason-1 Interlevead orbit	February 2009 – March 2012 (3 years)	262 – 374
Geaosat Follow On	Geaosat Follow On	January 2000 – September 2008 (8 years)	37 – 222

Table 3: Variance of the differences between gridded (L4) DT2018 two-sat-merged products and independent TP interleaved along-track measurements for different geographic selections (unit = cm²). In parenthesis: variance reduction (in %) compared with the results obtained with the DT2014 products. Statistics are presented for wavelengths ranging between 65-500 km and after latitude selection (|LAT|<60°).

	TP [2003-2004]
Reference area*	1.4 (-0.3%)
Low variability (<200 cm²) & offshore (distance coast >200 km) areas	5.0 (-3.0%)
High variability (>200 cm²) & offshore (distance coast >200 km) areas	37.7 (-3.1%)
Coastal areas (distance coast < 200km)	8.2 (-10.1%)
Intertropical belt (±20°N)	4.8 (-9.1%)

*The reference area is defined by [330, 360°E]; [-22, -8°N] and corresponds to a very low-variability area (between 0 and 7 cm²) ~~area~~ in the South Atlantic subtropical gyre where the observed errors are small.~~l~~

Table 4: Variance of the differences between gridded geostrophic current (L4) DT2018 products and independent drifter measurements (unit = cm2/s2). In parenthesis: variance reduction (in %) compared with the results obtained with the DT2014 products. Statistics are presented for latitude selection (5°N<|LAT| < 60°N).

	Zonal	Meridional
Reference area*	44.3 (-1.8%)	33.4 (-0.9%)
~~Dist coast > 200km & variance < 200 cm²~~ Low variability (<200 cm²) & offshore (distance coast >200 km) areas	91.6 (-6.1%)	88.6 (-6.7%)
High variability (>200 cm²) & offshore (distance coast >200 km) areas~~Dist coast > 200km & variance > 200 cm²~~	229.6 (-4.3%)	260.5 (-4.5%)
Coastal areas (distance coast < 200km)~~Dist coast < 200km~~	189.7 (-14.7%)	195.3 (-15.5%)
Intertropical belt (±20°N)	170.5 (-18.8%)	176.2 (-37.9%)

The reference area is defined by [330, 360°E]; [-22, -8°N] and corresponds to a very low-variability ~~area~~area (between 0 and 7 cm²) in the South Atlantic subtropical gyre where the observed errors are small

Table 5: Variance of the differences between gridded (L4) DT2018 two-sat-merged regional Mediterranean (first line) and Black sea (second line) products and independent TP interleaved along-track measurements without filtering over the time period 2003-2004 (unit = cm²). In parenthesis: variance reduction (in %) compared with the results obtained with the DT2014 products.

	TP [2003-2004] unfiltered
Mediterranean Sea product	16.7 (-4.2%)
Black Sea product	23.2 (-3.5%)

Table 6: RMSE (m/s) and correlation coefficient between the absolute geostrophic velocities derived from DT-2018 regional products for the Mediterranean Sea; and absolute surface velocities as obtained from drifters collected in the basin. The variance of the datasets (m^2/s^2) and the data used to conduct the comparison are also displayed.

	DT-2018 regional	DUACS-DT2018 improvements
R	0.49	4 %
RMS diff (m/s)	0.12	1 %
variance drifter (m^2/s^2)	0.017	-
variance altimetry (m^2/s^2)	0.008	14 %

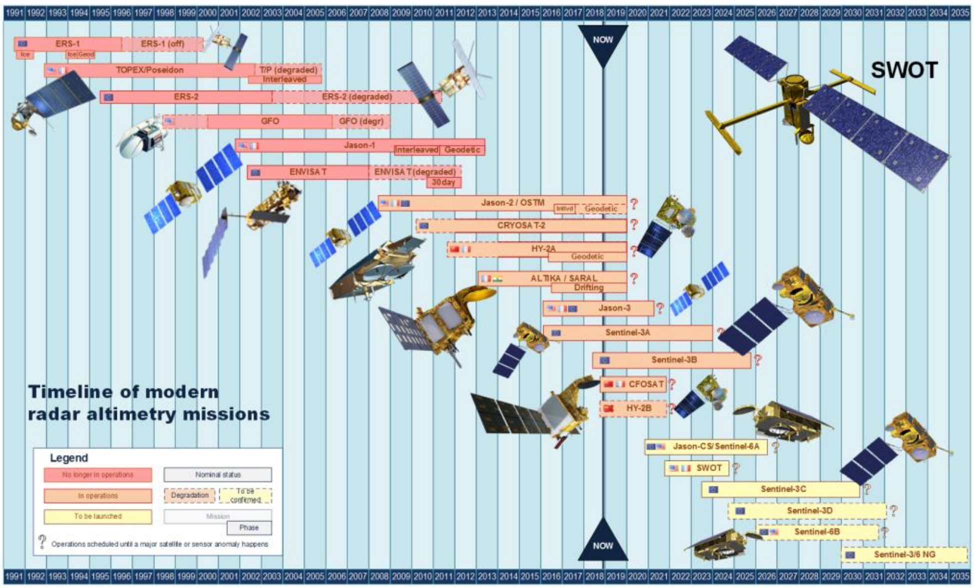

Figure 1: Timeline of the altimeter missions used in the multi-mission DUACS -DT T2018 system.

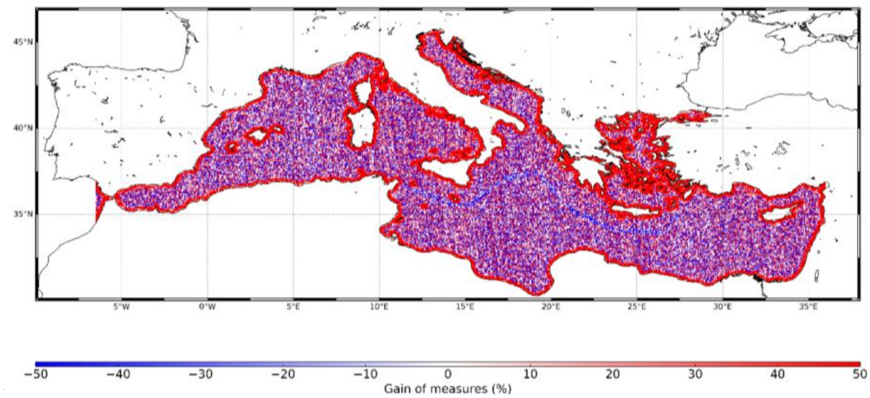

Figure 2: Gain in percent of Cryosat-2 L2P data in DT-2018 version compared to the DT-2014 version for the Mediterranean Sea product. Gain of points with the DT-2018 version are is in red, lLoss of points is in blue.

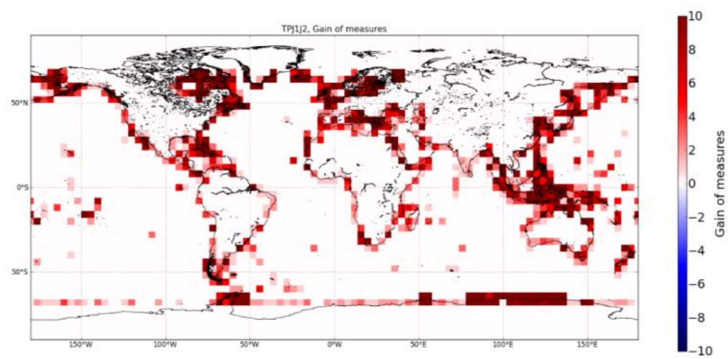

Figure 23: Gain of measurements in the Topex/Poseidon-Jason1-OSTM/Jason-2 Mean Profiles used in DT-2018 versions compared to the DT-2014. Gain of points in the DT-2018 version are is in red, loss of points is in blueLoss ones in blue.

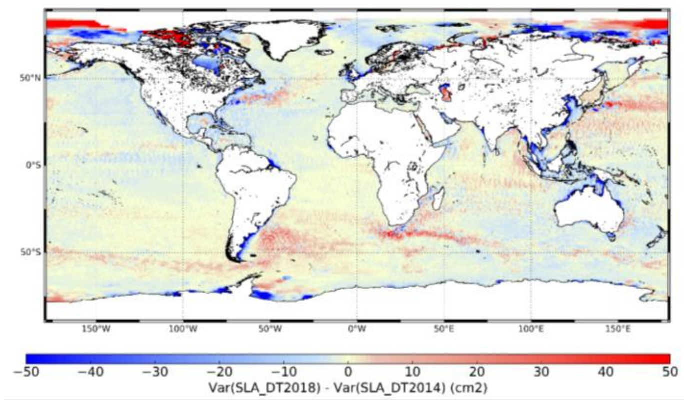

Figure 34: Difference between SLA variance observed observed with DT2018 and DT2014 gridded products and SLA variance observed with DT2014 gridded products over the time period 1993-2017 period. Units: cm^2.

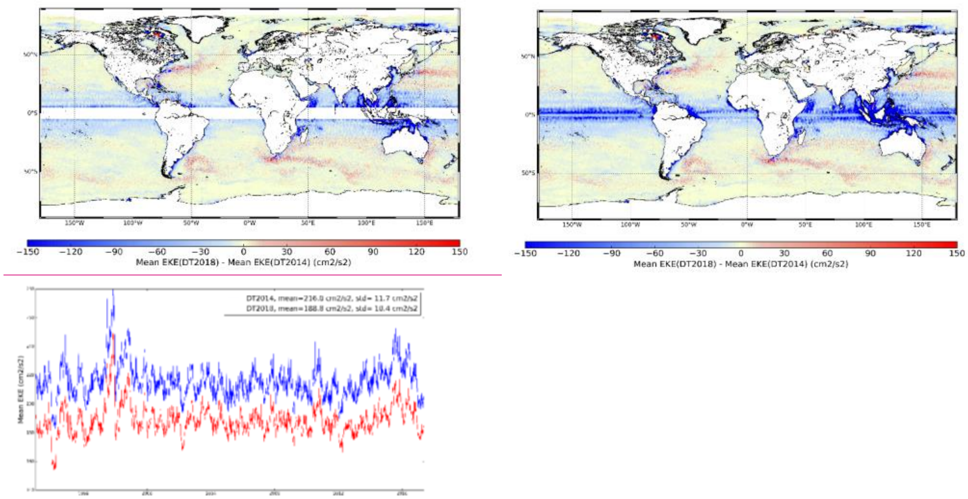

Figure 45: Map of the difference between mean EKE mean difference betweenfor DT2018 and DT2014 gridded products (left frame) and evolution of the mean EKE over global ocean, computed from DT201 EKE time series (right frame) computed from DT20144 (blue line) and from DT2018 (red line) SLA gridded products over the time period 1993-2017 period. The ±5°N equatorial belt has been removed Units: cm^2/s^2.

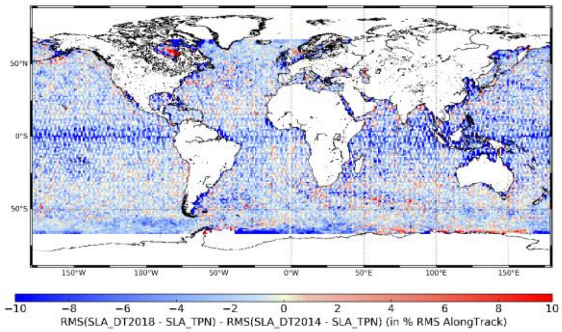

Figure 5: Difference of the ~~Root Mean Square~~RMS of the difference between gridded ~~the altimeter~~ SLA products and ~~minus~~ independent Topex/Poseidon interleaved, along-track SLA measurements, using successively DT2018 and DT2014 ~~SLA~~ version~~gridded products~~. Negative values represent reduced~~mean that the SLA~~ differences between DT2018 altimetry products and independent along-track measurements ~~are reduced when considering DT2018 products~~.

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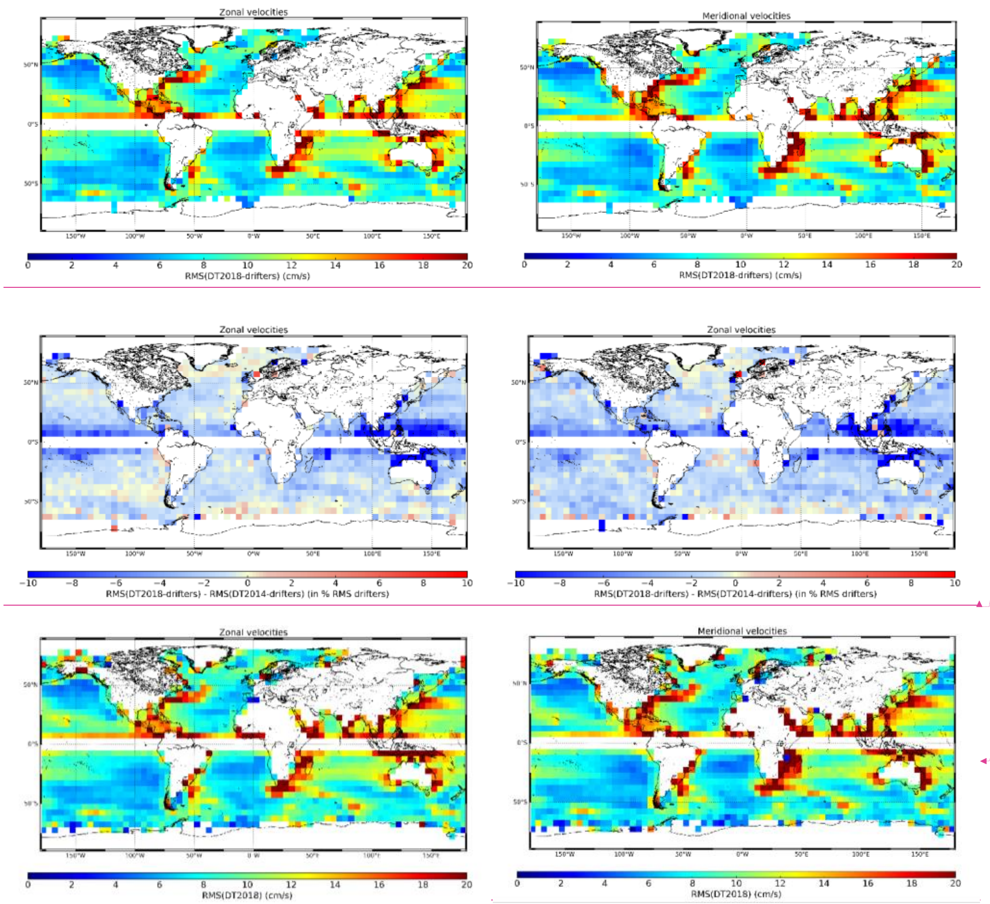

Figure 6:

Figure 6: Upper panels: **Zonal (left) and meridional (right) RMS of the difference between DUACS DT2018 absolute geostrophic current and drifter** 's **measurements over the** 1993-2017 **period** [1993-2017]**.** Lower panels: Zonal (left) and meridional (right) difference of the RMS of the altimeter geostrophic currents minus drifters measurements, using successively DT2018 and DT2014 gridded products. Negative values represent reduced differences between DT2018 altimetry products and drifters. The statistic is expressed as a percentage of RMS of drifter measurements **Statistics have been computed in boxes of 5°x5°.** (units: cm/s). Boxes with less than a thousand1000 points have been masked. Difference of the variance RMS of the altimeter SLA minus Drifters SLA differences, using successively DT2018 and DT2014 SLA gridded products. Negative values mean that the SLA differences between altimetry and drifters are reduced when considering DT2018 products.

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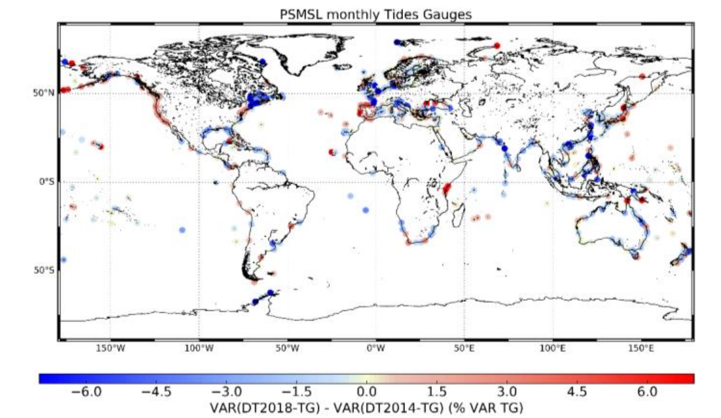

Figure 7:

~~Figure 7:~~ Difference of the variance between~~of the~~ ~~altimeter~~ gridded SLA products ~~minus~~ and TG ~~SLA differences~~, using successively DT2018 and DT2014 ~~SLA~~ gridded products. We used mean monthly TG measurements from the PSMSL network~~Monthly Tide Gauges come from PSMSL network~~. Negative values represent reduced~~mean that the~~ ~~SLA~~ differences between DT2018 altimetry gridded SLA ~~altimetry~~ and TG~~s are reduced when considering DT2018 products~~. The statistic is expressed as a percentage of RMS of TG measurements.

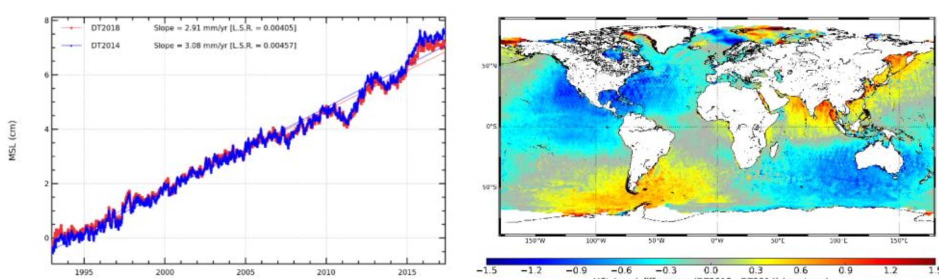

Figure 8:

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~~Figure 8:~~ Left panel: temporal evolution of the ~~global~~ GMSL estimated from DT2018 (red line) and DT2014 (blue line) gridded SLA products. The annual and semi-annual signals ~~have been~~were adjusted and no GIA correction ~~has been~~was applied. Right panel: map of the differences of the local MSL trend estimated from the DT2018 and DT2014 gridded SLA products. MSL was estimated over the 1993-2017 period.

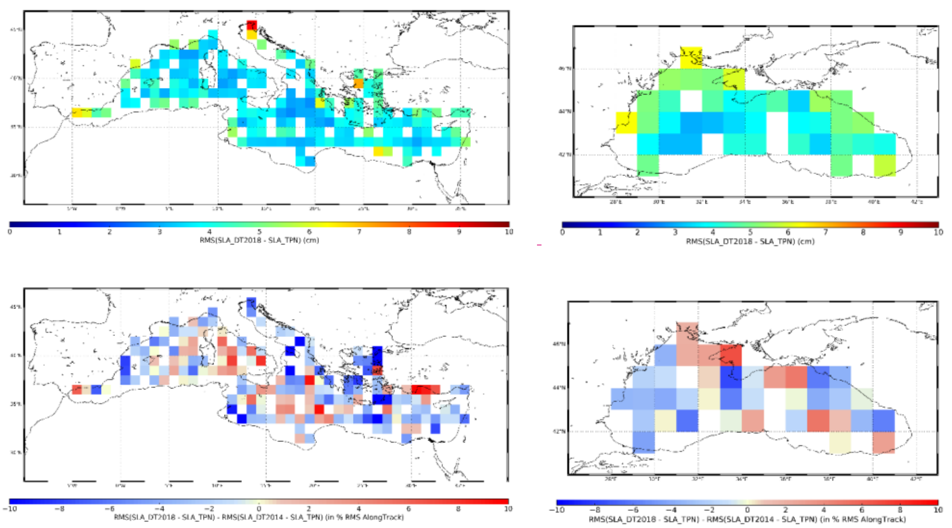

Figure 9:

~~Figure 9:~~ Difference of the RMS of the difference between gridded regional Mediterranean Sea (left frame) and regional Black Sea (right frame) SLA **products and independent Topex/Poseidon interleaved along-track SLA measurements, using successively DT2018 and DT2014 version. Negative values represent reduced differences between DT2018 altimetry** products and independent along-track measurements. **The statistic is expressed as a percentage of RMS of the independent along-track product.** ~~RMS of the difference between regional Mediterranean Sea (left frame) and regional Black Sea (right frame) gridded DUACS DT-2018 sea level anomaly and independent TP along-track measurements over the period [2003-2004] (units: cm). The histogram above the colorbar indicates the number of occurrences of each value in the RMS map.~~

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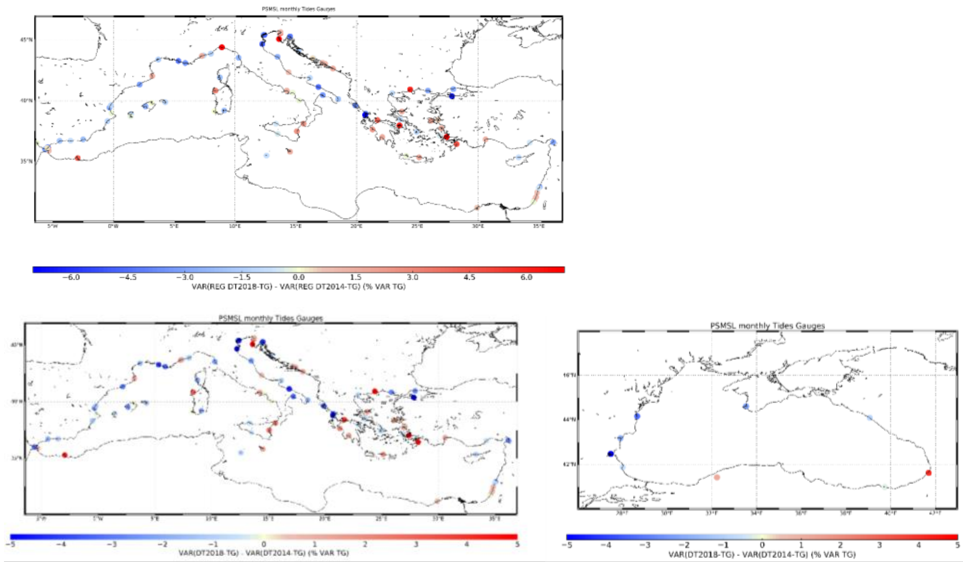

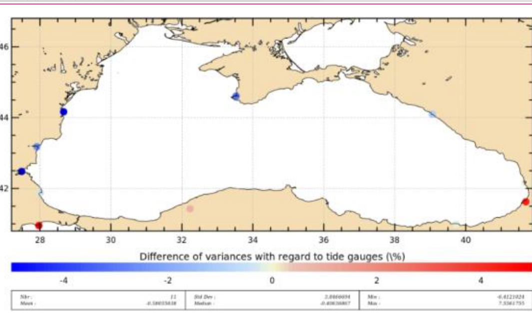

Figure 10:

~~Figure 10:~~ Difference of the variance between regional Mediterranean gridded products (upper frame) and regional Black Sea products (lower frame) SLA products and TG, using successively DT2018 and DT2014 gridded products. We used mean monthly TG measurements from the PSMSL network. Negative values represent reduced differences between DT2018 altimetry gridded SLA and TG. The statistic is expressed as a percentage of RMS of TG measurements. The statistic is expressed as a percentage of RMS of the independent along-track product.~~Difference of the variance of the altimeter SLA minus TG SLA differences, using successively DT2018 and DT2014 SLA regional Mediterranean gridded products~~ (upper frame) and regional Black Sea products (lower frame)~~. Monthly Tide Gauges come from PSMSL network. Negative values mean that the SLA differences between altimetry and TGs are reduced when considering DT2018 regional Mediterranean gridded products.~~

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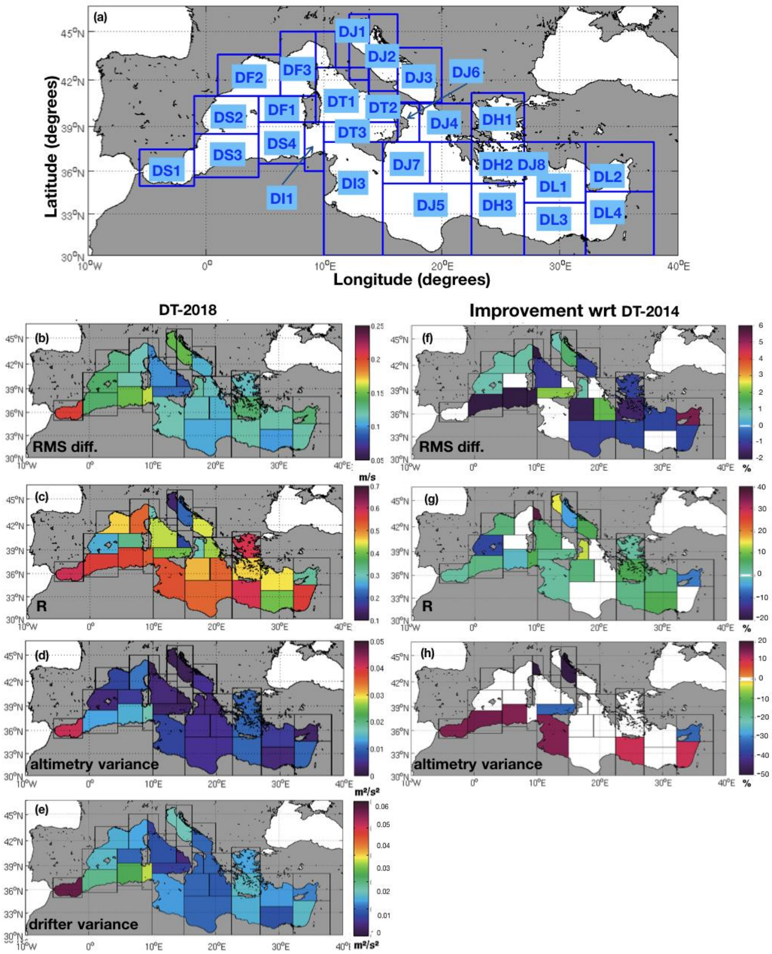

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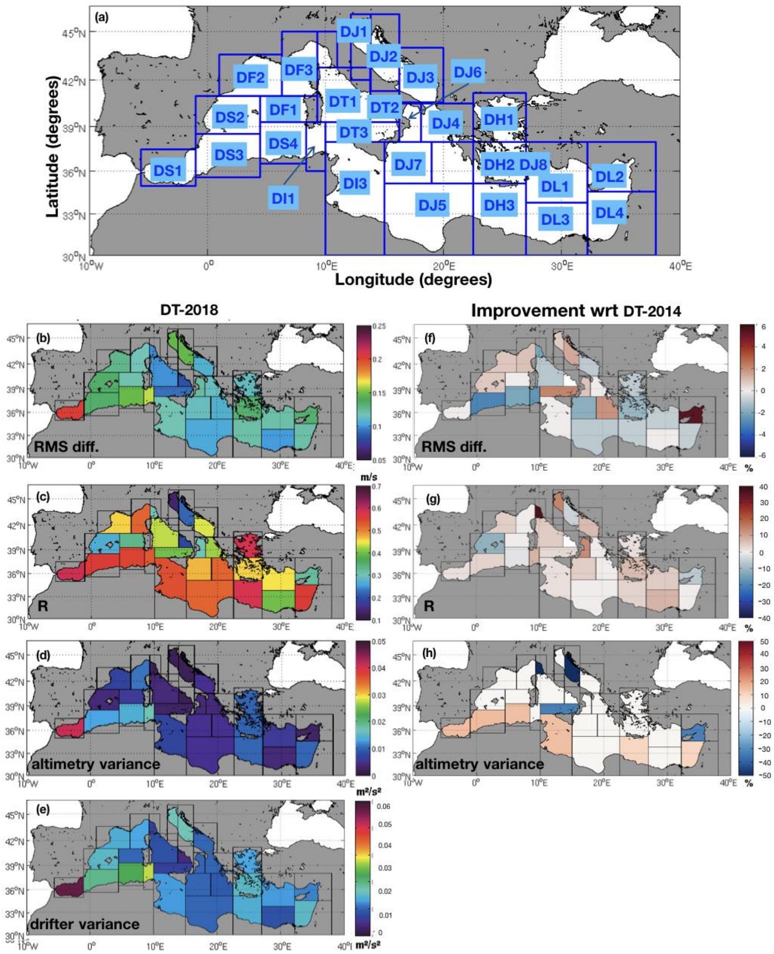

Figure 11:

~~Figure 11:~~ **(a) Map of the Mediterranean Sea showing the geographical limits and the nomenclatures of the regions (blue boxes) as defined in Manca et al. (2004) where drifter data is available in the western sub-basin: Alboran Sea (DS1), Balearic Sea (DS2), western and eastern Algerian (DS3 and DS4), Algero-Provençal (DF1), Liguro-Provençal (DF3, DF4), Gulf of Lion (DF2),Tyrrhenian Sea (DT4), Sardinian channel (DI1), Tyrrhenian Sea (DT2, DT3) and Sicily Strait (DI3); and in the eastern sub-basin: Adriatic Sea (DJ1, DJ2, DJ3), Ionian Sea (DJ4, DJ5, DJ6, DJ7, DJ8), Aegean Sea (DH1, DH2), Cretan Passage (DH3) and**

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Levantine basin (DL1, DL2, DL3, DL4). Left column: maps of the Mediterranean Sea showing the comparison between DT-2018 regional altimetry product with the drifter in-situ observations within the geographical limits and the nomenclatures of the regions defined in (a). The statistical parameters showed are: (b) RMS difference; (c) correlation coefficient; (d) altimetry variance and (e) drifter variance. Right column: improvements (%) of the comparisons between the DT-2018 regional product and drifter in-situ observations with respect to the comparisons by using the DT-2014 product within the geographical limits and the nomenclatures of the regions defined in (a). The statistical parameters showed are: (f) RMS difference; (g) correlation coefficient and (h) altimetry variance. Positive values denote an improvement of DT-2018 regional product over DT-2014.