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Benefits of the Adaptive retracker for improving Jason-3 GMSL estimations

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Context

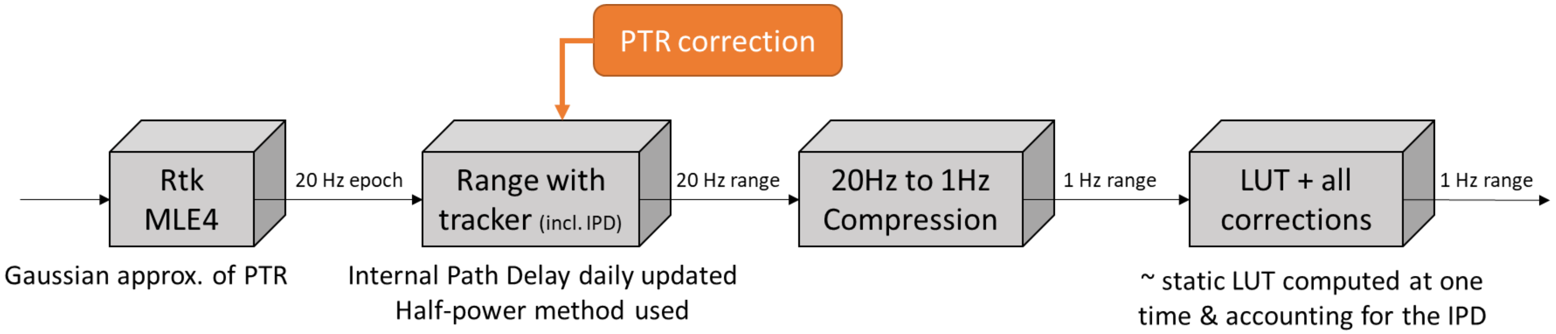
- In the frame of the Jason-3 GDR-F reprocessing campaign, the **Adaptive retracker solution** was implemented together with many other evolutions related to the geophysical corrections. The outputs of the Adaptive solution will be provided in the GDR-F products in addition to the historical MLE-4 solution
- An in-depth analysis of the differences between the MLE4 and the Adaptive solutions was performed
- In particular, many valuable improvements linked to the Adaptive algorithm were observed but it is not the objective of this talk to report on them (*cf Roinard&Bignalet talk on GDR-F reprocessing in calval session*). A dedicated paper will be issued next year when the reprocessing is sufficiently advanced *(Roinard&al, to be published in 2021)*

- **A special attention was paid to the range drift analysis that directly impacts the GMSL estimation and its accuracy.**
- This presentation provides the main outcomes of the study, highlighting the benefits of using the Adaptive solution for GMSL estimation
- Impacts on other missions (Jason-1, Jason-2, Sentinel-6) are also addressed

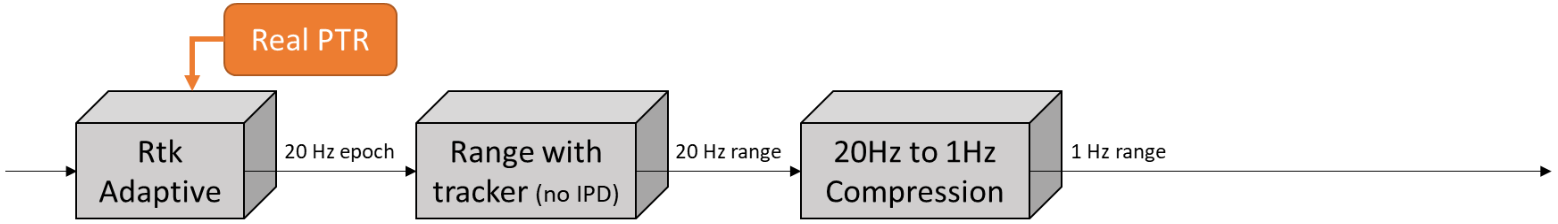
Description of J3 GDR-F evolutions with potential impacts on GMSL

For the Jason-3 GDR-F reprocessing campaign, two different retracking solutions have been implemented:

- ❑ The historical chain, including MLE4 and Look Up Tables



- ❑ A new numerical solution called **<u>Adaptive solution</u>** which performances/advantages/drawbacks have been presented many times at OSTST *(Thibaut, EUM conference, 2016; Poisson, OSTST 2016; Thibaut, OSTST 2017, …)*



Description of J3 GDR-F evolutions with potential impacts on GMSL

- ❑ In the historical GDR (and current GDR-D) solution:
  - ✓ the Look Up Tables have been computed once *(Thibaut et al, Marine Geodesy, 2004)* and have not been updated since Jason-3 launch
  - ✓ the PTR is continuously monitored throughout the entire life of the mission to assess its evolution due to the ageing of the electronic components
  - ✓ the drift of the PTR impacting the range estimation (called Internal Path Delay) is computed daily (and stored in the Long Term Monitoring File). It is accounted for in the range/SLA computation. The computation of the PTR drift is consistent with the way LUT are computed
  - ✓ **However**, evolutions of the global shape of the PTR are not accounted for, because the LUTs have not been updated during the mission (evolution of main or side lobes asymmetries for instance)
  - ✓ **The MLE4 solution** provided in the GDR-F products is consistent with the current GDR-D version

- ❑ One major improvement of the Adaptive solution is related to the fact that the **real PTR** is **numerically introduced in the retracking algorithm** making the 1Hz Look Up Table correction unnecessary.
- ❑ **All drifts or instabilities of the PTR are thus « natively » accounted for** (without any approximation) in the Adaptive solution making this solution an excellent reference for evaluating and confirming the quality of the current GMSL estimation.

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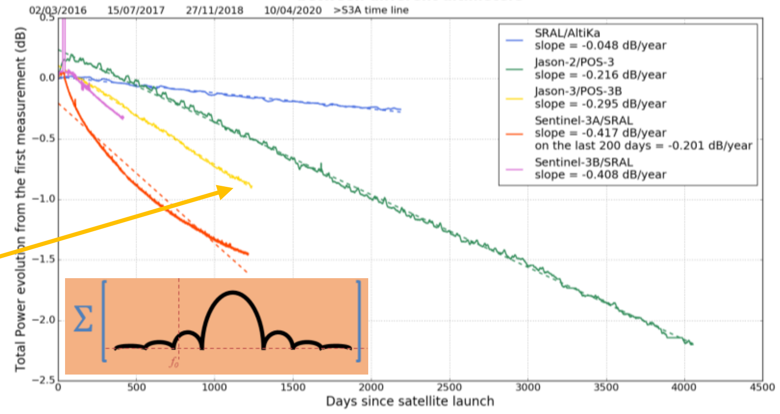
Evolution of the PTR shapes of various altimeter missions

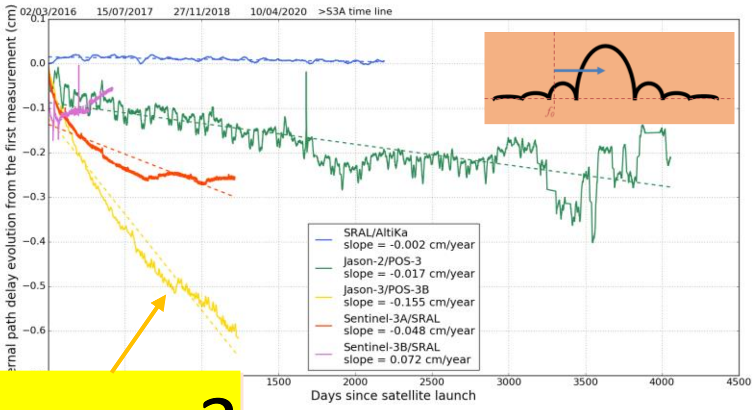
- **Some of the PTR evolutions are taken into account** in the ground processing (impacts on sigma0 and SSH)

Total Power of the PTR



Jason-3

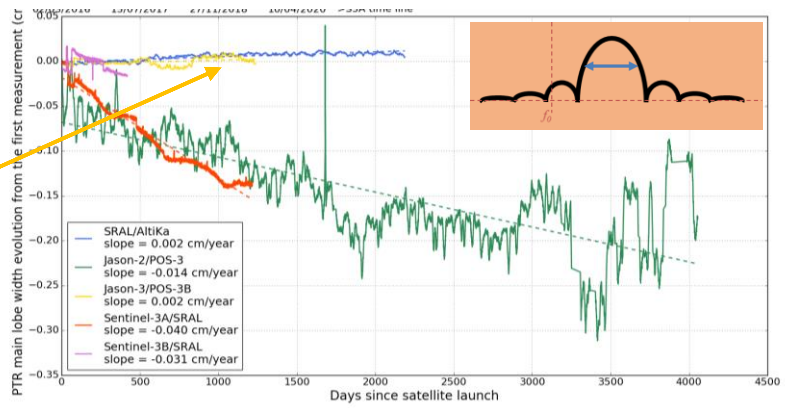
Internal path delay of the PTR



Jason-3

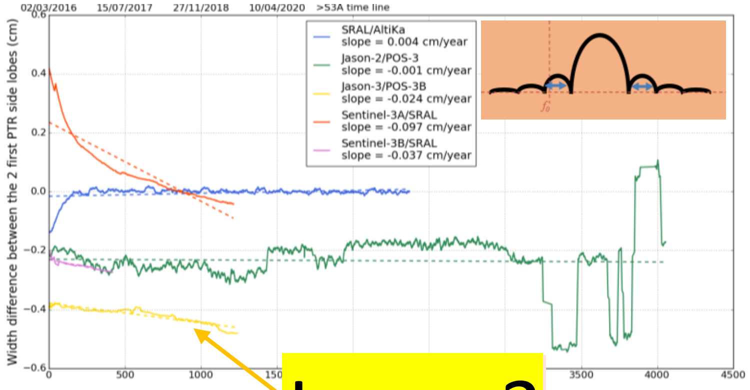
- **Some of the PTR evolutions aren't & can't be taken into account** in the ground processing (sigma0/SWH/SSH)

Main Lobe Width



Jason-3

Difference of width of the first PTR lobe



Jason-3

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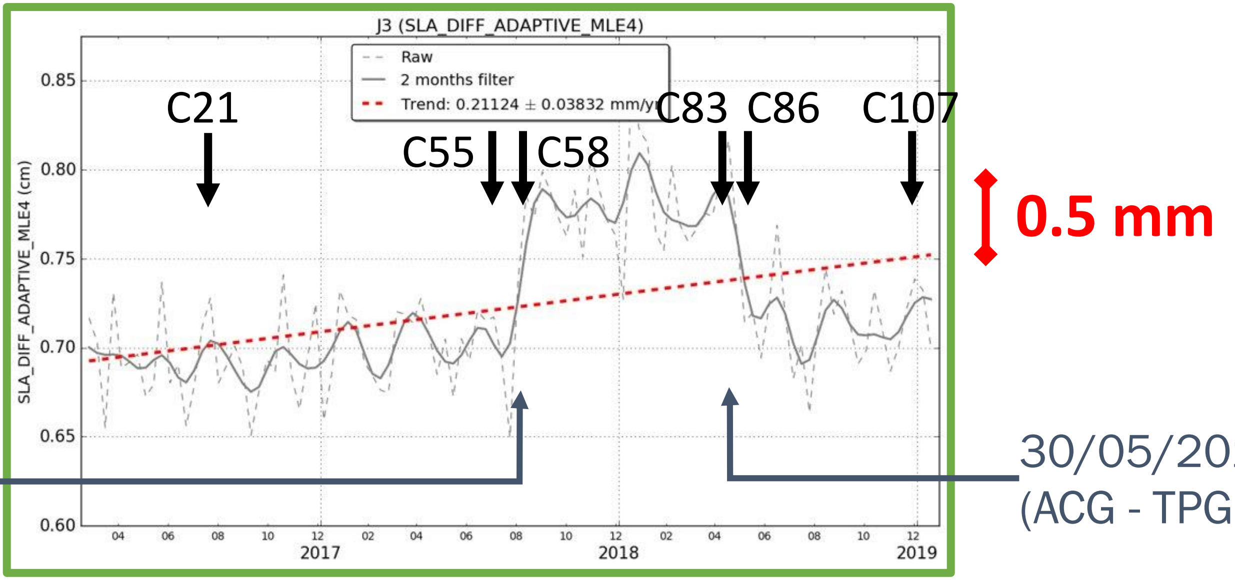
Comparison of the two GDR-F solutions with impacts on GMSL (Jason-3)

- The difference of SLA means (Adaptive – MLE4) shows a very good consistency between the two solutions but **a bias of about 7 mm and a slope of about 0.2 mm/year** which is comparable to the most important uncertainty among the different errors contributing to the GMSL estimation uncertainties. This difference is thus significative for climate studies.



31/08/2017 : DEM upload (reset)

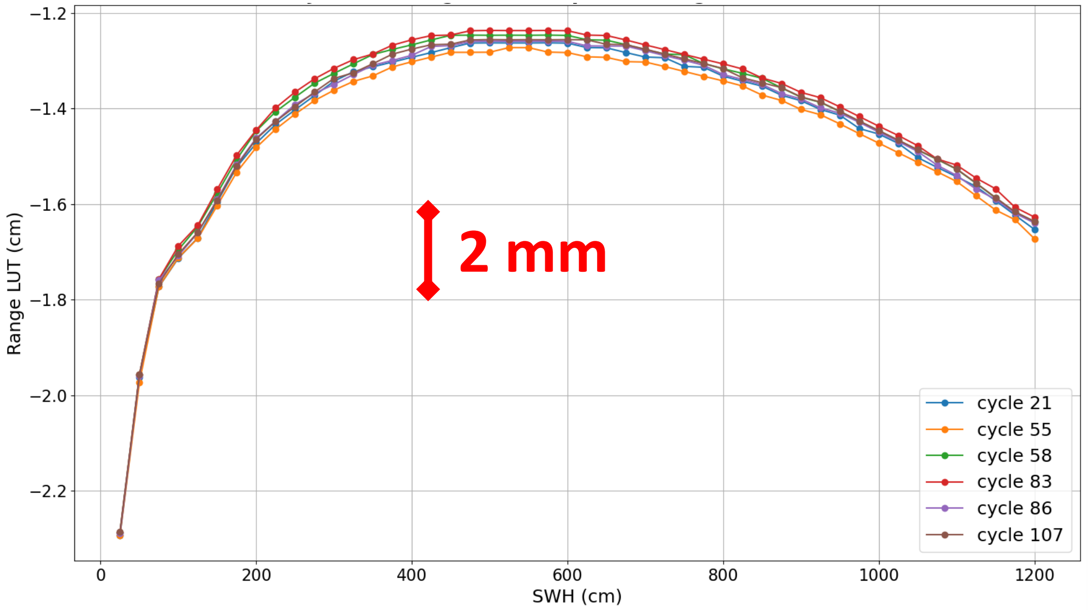
30/05/2018 : BDR update (ACG - TPG modifications in EEPROM)

- Jumps can be observed after the instrument reset (upload of the DEM) and BDR update, which indicates that potential changes in the PTR have occurred and that these changes may not have been accounted for in the internal path delay. We recall that the LUT have been computed only once at the beginning of the mission and never updated since then.

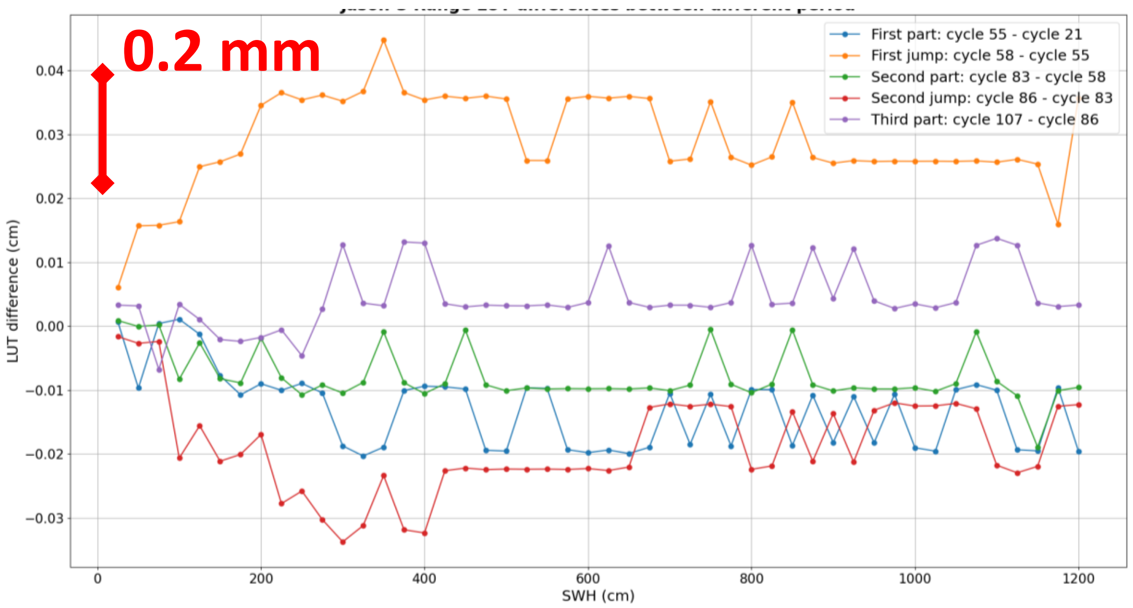
Comparison of the two GDR-F solutions with impacts on GMSL (Jason-3)

- ❑ A new set of LUTs has been generated, at different dates that correspond to the observed jumps (just before and just after) in order to see if modifications of the PTR shapes could explain the jumps
- ❑ LUT have thus been generated at cycles 21, 55, 58, 83, 86, 107 (LUT that is used has been computed just after the launch)

Jason-3 range LUT at different cycles



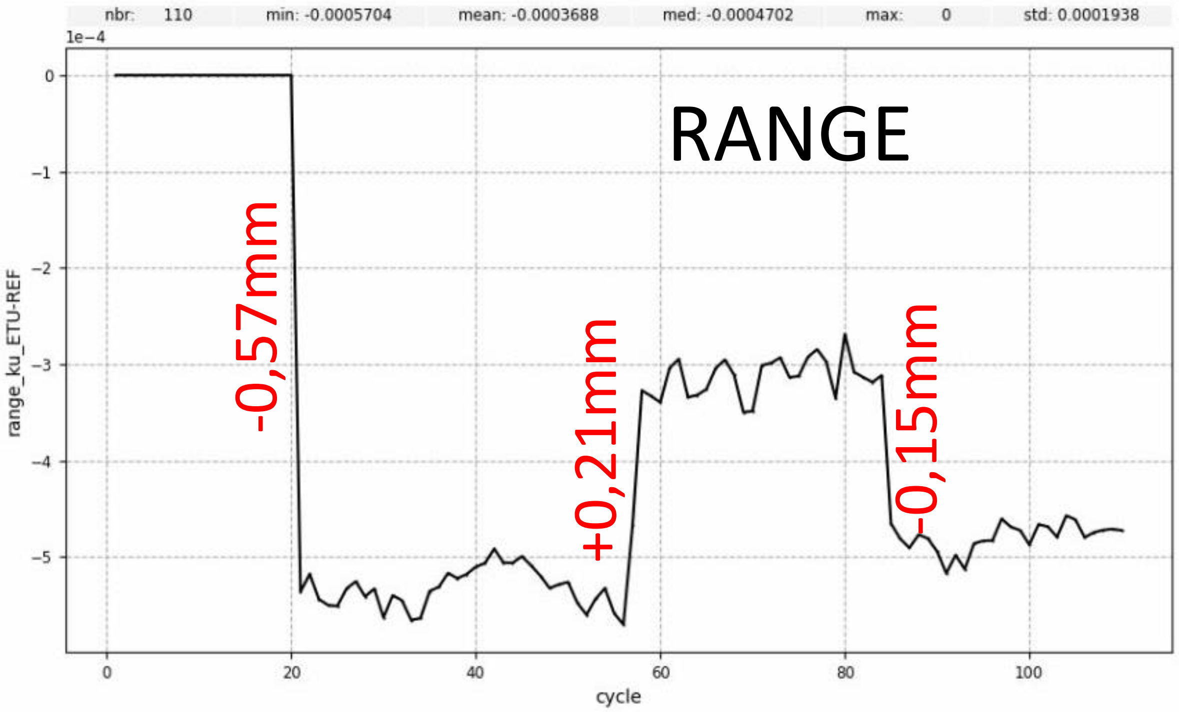
Difference of Jason-3 range LUT around the different jumps



- ❑ Clearly, the shapes of the LUT are evolving. For medium waves of 2.5m:
  - ✓ First jump between cycle 55 and 58 is about +0.4 mm
  - ✓ Second jump between cycle 83 and 86 is about –0.3 mm

Comparison of the two GDR-F solutions with impacts on GMSL (Jason-3)

- When applying the new LUTs (range and SWH) to the dataset, jumps appear at the positions already mentioned, cleary showing that the instrument has undergone evolutions that are not perfectly undertaken by in the internal path delay correction.



Cycle 21 LUTs have been applied from cycle 21 but should be applied from cycle 4 (instrumental restart at cycle 3 track 181). Very weak impact on the SWH can be observed with variations of one/two milimeters

Conclusions for Jason-3

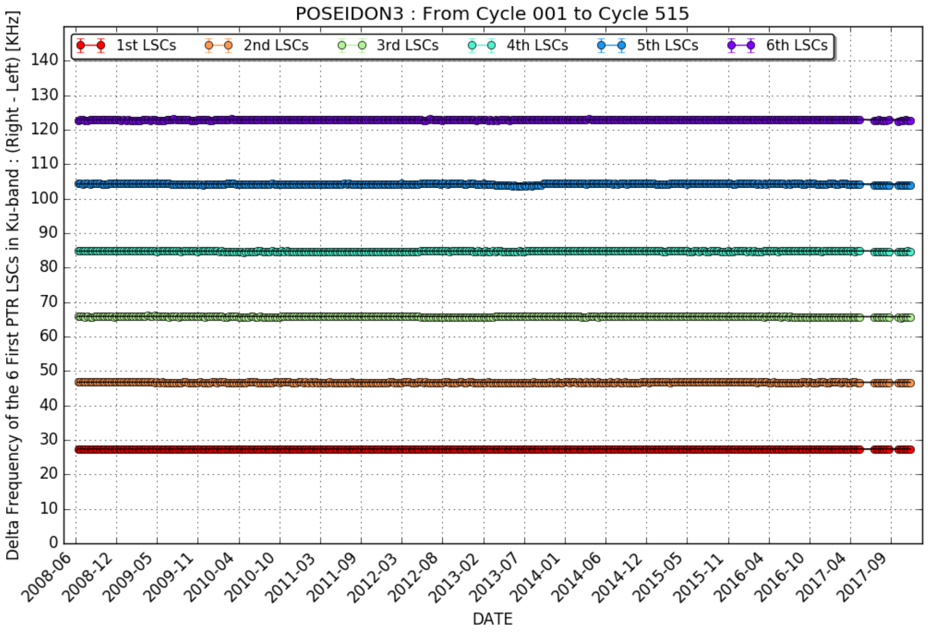
- **<u>For the first time</u>,** a new method (**<u>Adaptive retracking</u>**) that fully accounts for the instrumental characteristics (monitored by the mean of its Point Target Response) is confirming the results obtained by the historical method (MLE4 + LUT + Internal Path Delay correction) when looking at the drift of the GMSL
- **<u>But a difference of 0.2mm/year is observed</u>** (over a 3-year period) between the 2 methods. This is comparable to the most important uncertainty among the different errors contributing to the GMSL estimation uncertainties
- This difference of 0.2 mm/year is explained by the fact that subtle changes in the PTR (as for instance, assymmetrical distorsions of the energy in the secondary lobes of the PTR) cannot be captured by the Internal Path Delay correction that is the historical correction applied to account for PTR modifications
- Improving the Jason-3 dataset using the current processing method and guaranteeing such a precision appears to be very complex because it would require a continuous update of the LUT corrections (impossible to manage in real time)
- The Adaptive retracking solution clearly appears to be an excellent alternative to the current method making LUT and Internal Path Delay correction unnecessary.

- **<u>We clearly recommend to people interested by GMSL estimation, to use the GDR-F Adaptive dataset as a priority</u>**

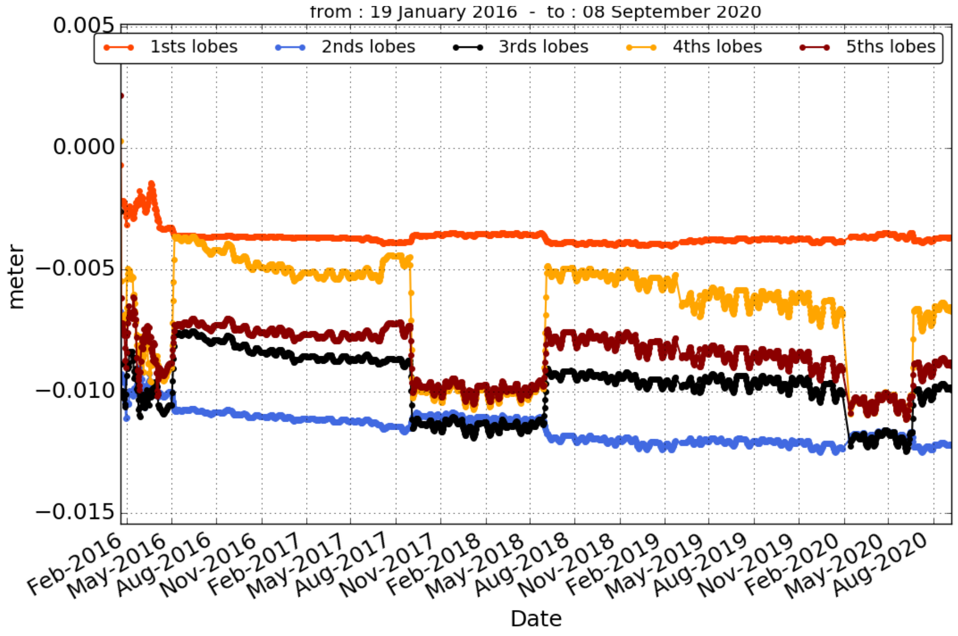
What about Jason-1 and Jason-2 ?

- Jason-1 and Jason-2 GDR-F have not yet been reprocessed as Jason-3 and no Adaptive retracker solution is available yet
- For Jason-2, the GDR-F reprocessing is planned to be done in 2021
- Similar comparison (Adaptive–MLE4) will be done on the GDR-F dataset when available but Poseidon-3 (on-board Jason-2) seems to be much more stable that Poseidon-3B (on-board Jason-3). Idem for Jason-1. To Be Confirmed

Position assymmetries between the two sides of the PTR for Jason-2



Position assymmetries between the two sides of the PTR for Jason-3



What About Sentinel-6 ?

- After the end of its commissionning phase in 2021, **Sentinel-6 will succeed to Jason-3 as the reference mission for computing the GMSL**
- Both Sentinel-6 LRM and SAR modes should provide comparable GMSL trends if the ageing of the instrument is properly accounted for in both modes (the ageing will be the same for both modes but with different ways to take its characteristics into account)
- Sentinel-6 embarks a new generation of instrument (Poseidon-4) with a full numerical chirp generator which should provide an instrument, very stable with time (this will need to be confirmed)
- Moreover, potentiel evolutions of the chirp characteristics (slope and phase) could occur and it will be possible to compensate for them by uploading on-board an evolutive chirp reference (that will be used for the deramping).

- We can thus anticipate a very good instrumental stability over time. But it will be crucial to carefully control the potential drifts of the instrument and their potential impacts on GMSL, either computed with LRM or SAR dataset.
- We simply want to mention that no « fully numerical » retracking solution is implemented right now in the ground segment (accounting for the exact and real PTR)

THANK YOU

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