CalVal Jason-3

Jason-3 validation and cross calibration activities

2021 executive summary

By succeeding to TOPEX/Poseidon, Jason-1 and Jason-2 on their primary ground track, Jason-3 has extended the high-precision ocean altimetry data record [[1]]. It was launched on January 17th 2016.
During Jason-3 tandem phase with Jason-2 (February 12th to October 2nd 2016), both satellites were on the same ground-track (with only 80 seconds delay), which is a unique opportunity to precisely assess parameter discrepancies between both missions and detect geographically correlated biases, jumps or drifts. OGDR and IGDR products have been publicly available since June 30th 2016. OGDRs were generated in version "T" until cycle 18/pass 137, and then turned into "D" version. Concerning IGDRs, they turned from "T" to "D" version at cycle 14/pass 143 on June 27th. GDR products have been available in version "T" since early October 2016 (more details on products versions on Jason-3 handbook [[2]]). **From cycle 174 onwards (29/10/2020), IGDR and OGDR have been produced in standard F. The complete reprocessing to standard "F" of the GDR data was achieved during 2021.** [see OSTST2020 dedicated presentation[3]]. GDR data have been distributed in standard F from cycle 171 onwards (16/12/2020).
In order to insure the extension of the legacy of sea-surface height measurements, Sentinel-6 / Michael Freilich satellite was launched on November 21st 2020: it reached Jason-3 orbit at end of december. From cycle 179 onwards (18/12/2020), Jason-3 is used as a reference for Sentinel-6 tandem phase.
During each cycle, missing measurements were monitored, spurious data were edited and relevant parameters derived from instrumental measurements and geophysical corrections were analysed for OGDR, IGDR and GDR. Please note that analysis are done **over ocean** only, no assessment is done over hydrological targets.
Jason-3 can use two on-board tracking modes: Diode/DEM (open loop) and median tracker (more details in complete annual report). In addition, a tracking automatic transition is possible, which means that when authorized: acquisition mode switches automatically from autonomous DIODE acquisition mode over land to Diode/DEM over ocean and referenced inland water. In September 2020, an update of DEM (Digital Elevation Model) was uploaded during cycle 168. 21038 lakes, 4236 rivers and 1478 reservoirs have been added. As a result, hydrological targets increased from 4721 up to 31473 (+566% : 26752 new virtual stations).

Please note the change in orbit standard solution available in the products:

- **GDR-F data orbit solution is POE-F ;**
- **until Jason-3 cycle 094, MOE-E orbit standard is available in IGDR products (MOE-F from cycle 095 onwards) ;**
- **from Jason-3 cycle 113 onwards, MOE orbit standard uses both DORIS and GPS data.**

[1] https://www.aviso.altimetry.fr/?id=601&L=0
[2] https://www.aviso.altimetry.fr/fileadmin/documents/data/tools/hdbk_j3.pdf
[3] https://meetings.aviso.altimetry.fr/fileadmin/user_upload/tx_ausyclsseminar/files/CVL_J3_GDRF_ready_v02_ostst2020_02.pdf

Data availability

Data availability is excellent for Jason-3. Jason-3 presents 99.89% of data availability over ocean after removing specific events (99.98% for Jason-2, see figure 1). Such events occured only a few times over Jason-3 full period, but four times only during 2020. **No important event occured over 2021**:

- during cycle 3, where 21.02% of measurements are missing due to the GPS platform upload,
- during cycle 57, where 1.76% of measurements are missing due to the DEM-onboard upload.
- during cycles 112/113, where 79.89% (for cycle 112) and 24.21% (for cycle 113) of measurements are missing due to SHM from 24/02/2019 09:57:16 until 06/03/2019 08:44:21.
- during cycle 116, where 53.19% of measurements are missing due to SHM from 06/04/2019 23:17:22 until 12/04/2019 02:20:01.
- during cycles 146/147, SHM occured from 31/01/2020 04:51:17 until 05/02/2020 09:37:14, and another time from 05/02/2020 21:00:53 until 13:02:2020 08:42:44. Due to those SHM events, missing data rate is 38.94% for cycle 146 and 88.81% for cycle 147.
- during cycle 160, SHM occured from 15/06/2020 21:50:42 until 19/06/2020 07:32:46. Due to this SHM event, missing data rate is 33.58% for cycle 160.
- during cycles 173/174, there is a DORIS anomaly from 27/10/2020 13:23:01 until 29/10/2020 11:36:00. Due to this event, missing data rate is 12.80% for cycle 173 and 6.66% for cycle 174.

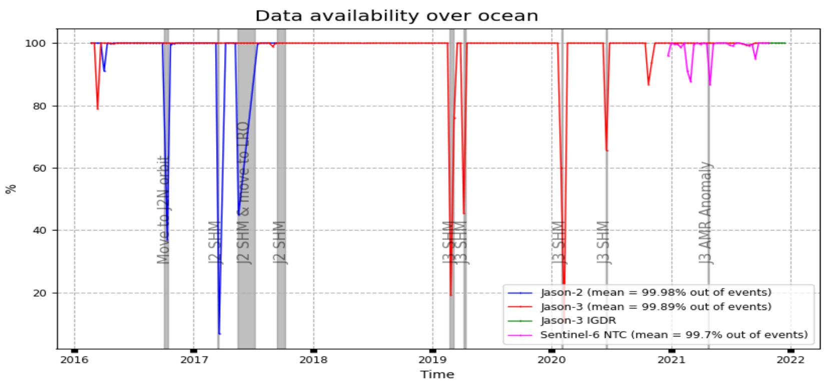

Figure 1 – Sentinel-6, Jason-2 and Jason-3 GDR data availability over ocean (per cycle)

Sea Level Anomalies

Over the tandem phase, the mean SLA differences between Jason-2 and Jason-3 data is stable in time with variations close to 1 mm rms (left of figure 2) and shows no drift. It presents only a weak hemispheric bias as both satellites measure the same oceanic features only 1'20" apart (figure 2) that corresponds to orbital signatures observed on sea surface height. The global average SSH bias is close to 2.6 cm using SSH corrections.

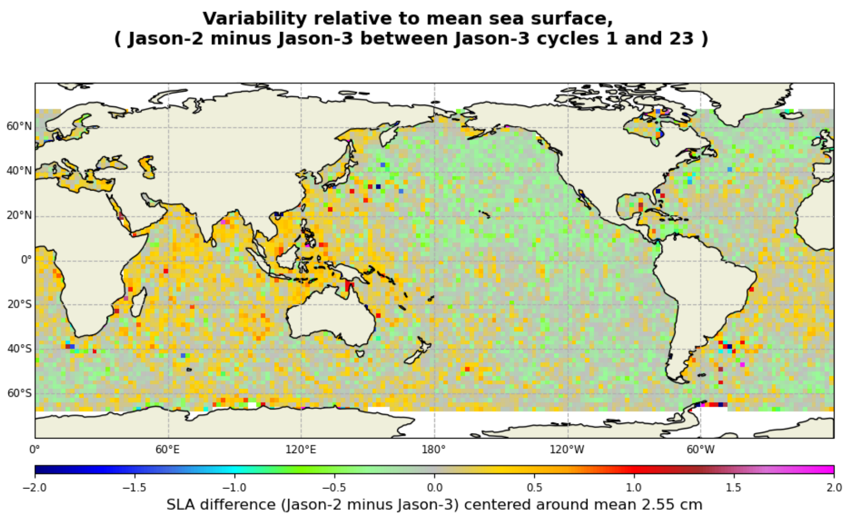

Figure 2 – Jason-3/Jason-2 tandem phase: until 02-10-2016. Map of SLA difference between Jason-2 and Jason-3 over tandem phase.

During Sentinel-6 tandem phase with Jason-3, the averaged difference of gridded SLA shows little difference between both missions as they have a very small temporal shift, similar to Jason-2/Jason-3 tandem phase.

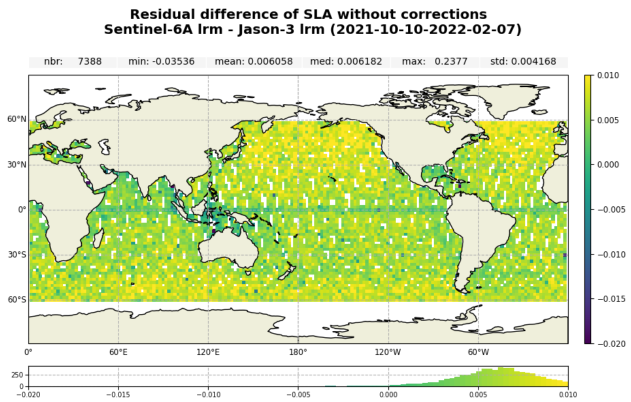

Figure 3 – GDR data. Map of Sentinel-6 and Jason-3 SLA differences for Jason-3 cycles 209 to 221

During the formation flight with Jason-2 (i.e. over cycles 25 to 46 from 12-10-2016 to 17-05-2017) and over Jason-2 LRO phase (until Jason-3 cycle 58, on 14-09-2017), average difference of gridded SLA for Jason-2 and Jason-3 shows high variability regions as Gulf Stream and Antarctic circumpolar currents are visible (figure 4). This difference is quite noisy as both satellites are shifted in time and sea state changes especially in regions of high ocean variability.

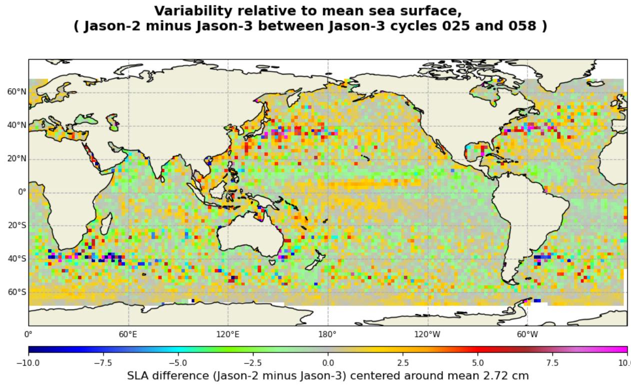

Figure 4 – GDR data. Map of Jason-2 and Jason-3 SLA differences for Jason-3 cycles 025 to 058

Performances at crossover points

Looking at SSH difference at crossovers (red curve on figure 5), a 120 day signal is way less visible than before on the mean for Jason-3 GDR data now that the orbit standard is homogeneous for the whole record (standard-F).
Concerning SSH error at crossover points ($standard\ deviation\ /\ \sqrt{2}$), Jason-3 mission show very good and stable performances with an error of 3.39 cm (3.48 cm for Jason-2). This satisfying performance is confirmed from cycle 15 onwards for Sentinel-6.

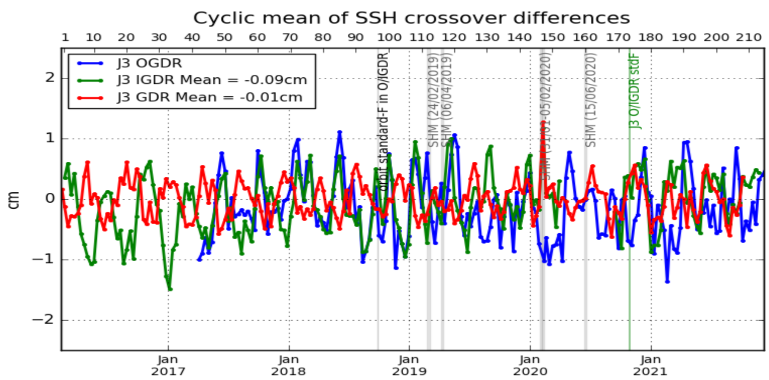

Figure 5 – Monitoring of mean of Jason-3 SSH crossover differences for OGDRs, IGDRs and GDRs. Only data with $|latitude|$ < 50°, bathymetry < -1000m and low oceanic variability were selected. (ocean_tide_sol1 = FES is used in SSH computation)

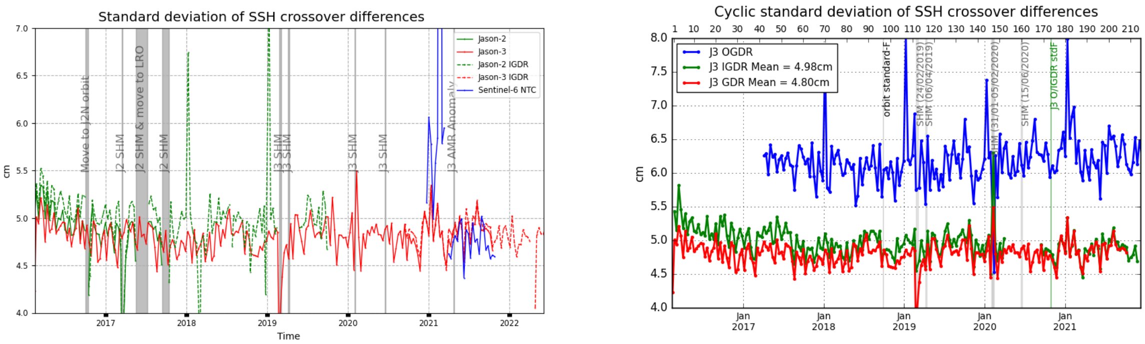

*Figure 6 – Cycle by cycle standard deviation of SSH crossover differences for Jason-2, Sentinel-6 and Jason-3 (**left**), and for Jason-3 using OGDRs, IGDRs and GDRs (**right**). Only data with $|latitude| <$ 50°, bathymetry $<$ -1000m and low oceanic variability were selected.*

The mean SSH differences at Jason 3/Jason 2 crossovers is quite stable and around 3cm in average (figure 7, left). The geographical pattern indicates some hemispheric biases: positive to the west, negative to the east (figure 7, right). It corresponds to orbital signatures observed on sea surface height.

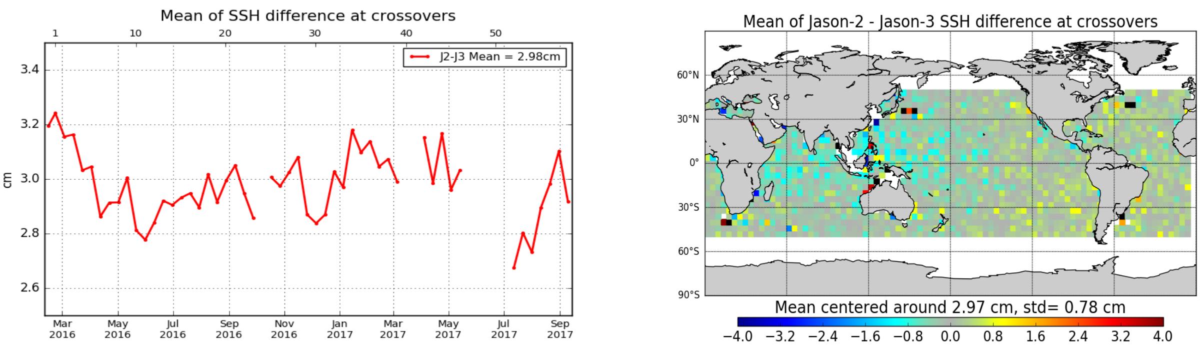

Figure 7 – Cyclic monitoring of Jason-2 - Jason-3 SSH crossover differences mean (left) and map over cycle 1 to 58 (right). Only data with $|latitude| <$ 50°, bathymetry $<$ -1000m and low oceanic variability were selected. GDR-D datasets are used for both missions on this figure

Contribution to Global Mean Sea Level

Since May 2016 (Jason-3 cycle 11), Jason-3 has been the reference altimetry mission to estimate the Global Mean Sea Level (GMSL), replacing Jason-2. Regional and global biases between missions have to be precisely estimated in order to ensure the quality of the reference GMSL serie. For more precisions, see the dedicated section on AVISO+ website [4].

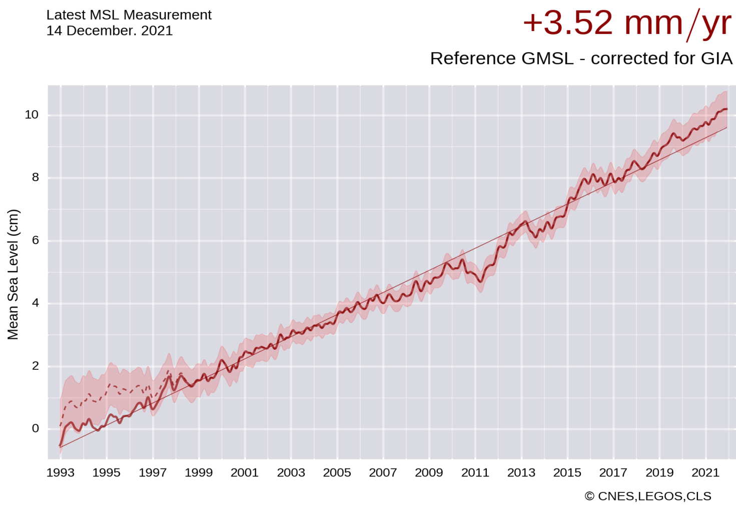

Figure 8 – Global (right) and regional (left) MSL trends from 1993 onwards.

Performances of the adaptive retracking method

The outputs of the adaptive retracking solution are distributed along the historical MLE3/4 ones. With the complete reprocessing of GDR data in standard "F", various diagnostics have been assessed to compare both adaptive and MLE4 products. See the article presenting the Adaptive retracking advantages for Jason-3 mission [5].

When checking the GMSL data, the adaptive solution conserves the stability of the GMSL record over the 5 years of data. Small differences observed are due to specific events (instrument resets). See the Mean Sea Level chapter of the Jason-3 Annual Report for more information.

The data availability and the along-track performance have been measured for both retrackers to assess the satisfying performances of the adaptive retracking solution. The report dedicated to the reprocessing in standard-F highlights the variance reduction when using the adaptive retracking (see figure 9).

There is a global bias of -2,28cm from MLE4 SLA to adaptive SLA. SLA MLE4 data are globally more rejected than SLA adaptive data (using recommended in handbook procedure). Taking into account valid points for both datasets, performances are better with adaptive solution than with MLE4 (except for coastal distance $< 10km$).

- variance of SSH difference at crossovers is reduced by -0,52cm2
- variance of along-track SLA is reduced by -0,18cm2

The 20Hz SLA and SWH spectrum also highlight the significant noise reduction when using the adaptive retracking solution.

[4] https://www.aviso.altimetry.fr/en/data/products/ocean-indicators-products/mean-sea-level.html
[5] https://www.aviso.altimetry.fr/fileadmin/documents/data/tools/NT-Thibaut_AdaptiveRetrackingForJason3GDRF.pdf

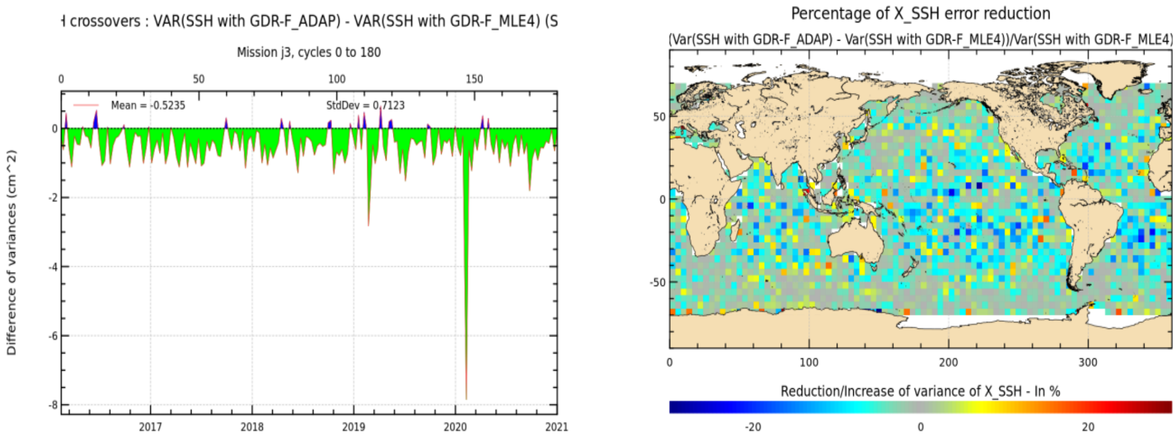

Figure 9 – Difference of SSH at crossover points : Variance difference (left) (selection on common valid points), percentage of error reduction (right).

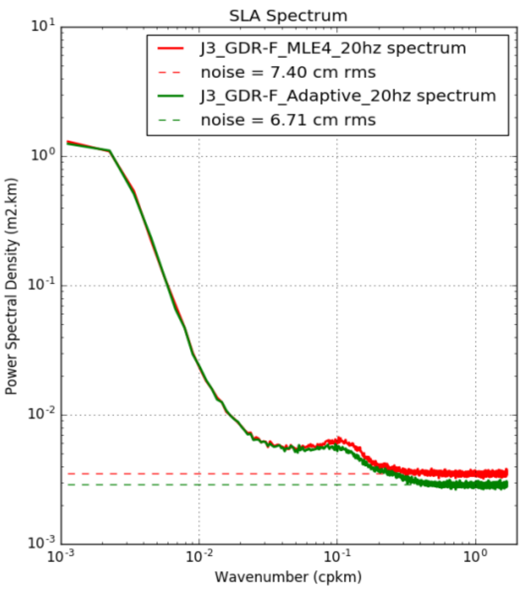

Figure 10 – SLA spectrum 20hz for cycle 174