Using Jason-2 Geodetic Mission to explorer possible EoL scenarios for Jason-3 for High Resolution Gravity Field Modelling

- Ole B. Andersen, oa@space.dtu.dk (DTU Space)
- Shengjun Zheng, DTU Space, North East University
- David Sandwell (Scripps Institute of Oceanography)
- Gerald Dibarboure (CNES)
- Walter Smith (NOAA)
- A. Abulaitijiang (DTU Space)

Abstract

- The Geodetic Mission (GM) of Jason-2 was planned to provide ground-tracks with a systematic spacing of 4 km after 2 years and 2 km after 4 years to increase the spatial resolution of global altimetric gravity fields. Jason-2 ceased operation after 2 years of GM providing a unique dataset. We highlight and evaluate the improvement to the gravity field which has been derived from the GM.

- The ageing Jason-2 suffered from several safe-holds and instrument outages. Here, we try to quantify the effect of safe-holds on marine gravity and discuss suitable approaches advising future GM like Jason-3. We evaluate the importance of attempting to "rewind" the mission to recover missing tracks.

- We also investigate the importance to high resolution marine gravity field determination of exploring the possibility to continue an existing GM by using the same orbital plane. The latter idea would allow bisecting the already 2-years Jason-2 GM creating a 2 km grid after 2 years of Jason-3 GM.

Jason 1 and 2 EoL Orbits characteristics

	Jason-1	Jason-2
Altitude	1324 km	1309 km
Period	7th May 2012 until 21 st of June 2013,	14th Sep 2017 until 1 st of October 2019,
LRO cycle length	406 days	371 days
GM total length	411 days	371+371 days = 742 days
Sub cycles	3.9, 10.9, 47.5, 179.5 days	4, 17, 79, 145 days

Orbital characteristic of the LRO of Jason-1 and Jason-2 satellites

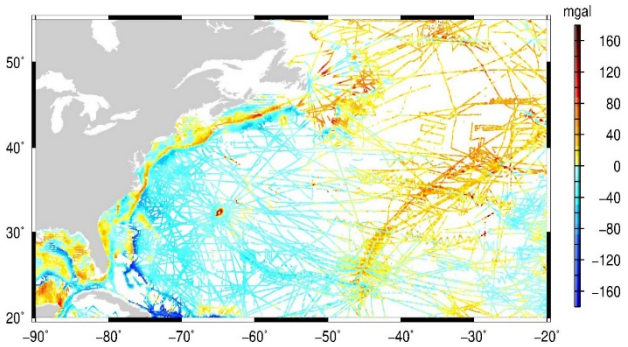
Jason 1 and 2 EoL safeholds

Satellite	Start date	End date	Duration
Jason-1	28/02/2013	18/03/2013	18 days
Jason-2 Cycle 1	14/09/2017	13/10/2017	30 days
	20/02/2018	02/03/2018	9 days
Jason-2 Cycle 2	19/10/2018	25/10/2018	6 days
	26/12/2018	07/01/2019	14 days
	16/02/2019	24/05/2019	100 days (21 days*)

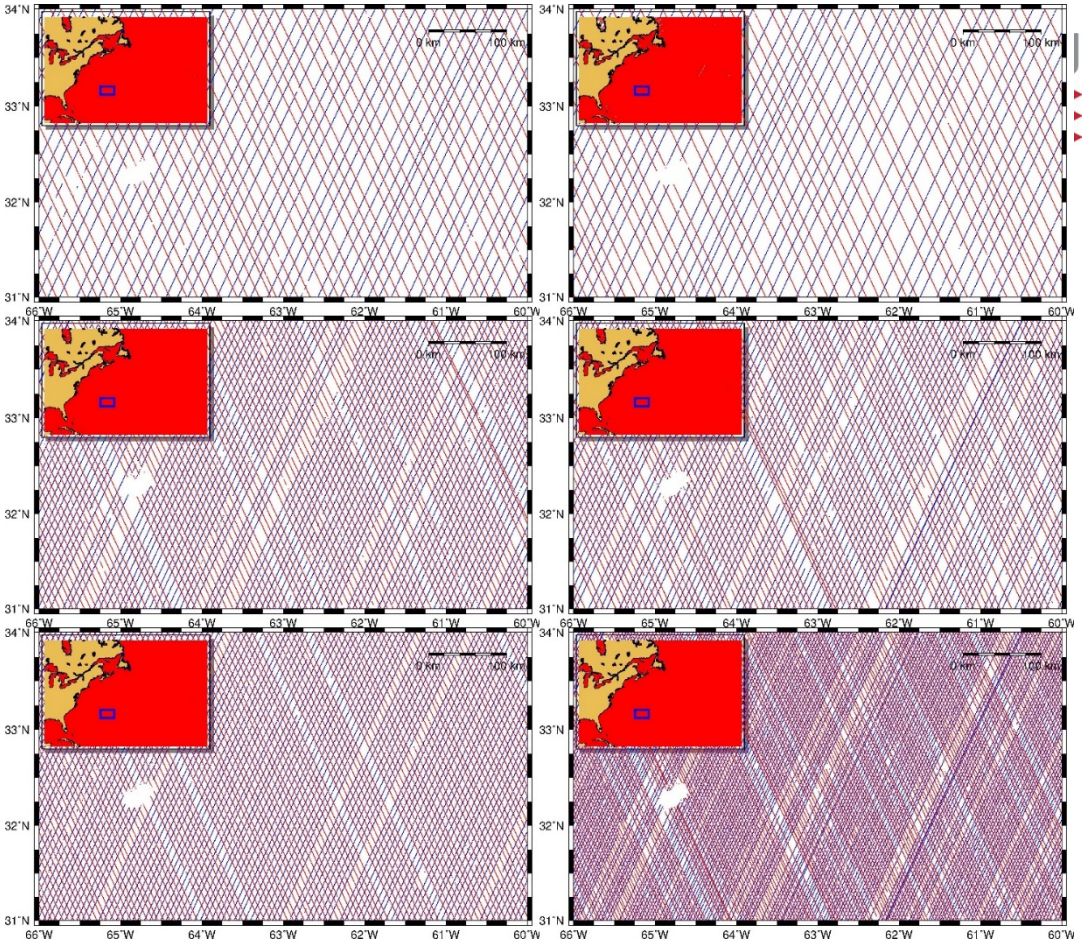
The last and most severe safe-hold lasted 100 days from February 16th, 2019 until May 24th 2019. The second LRO cycle should, in theory have be completed by July 31st 2019, but the partnership between NOAA, NASA and CNES agreed to conduct an orbital maneuver and "rewinded" the mission by 79 days to recover the missing geodetic observations. Rewinding the mission to recover gaps is possible because the LRO orbit is designed with multiple interleaved sub-cycles and a relatively cheap maneuver (in terms of fuel) can "rewind" the mission by a sub-cycle (e.g., 17, 79 or 145 days). It is, in theory, possible to rewind the mission by any amount of days, but at significant increased fuel cost and this is normally avoided. By rewinding the mission by 79 days the resulting gap in data collection due to the safe-hold was limited to 21 days.

Data

Geographic distribution of Jason GM altimeter measurements for a section in the NW Atlantic Ocean close to Bermuda. Upper left: J1 sub-cycle 1, Upper right: Jason 1 sub-cycle 2; Center left: J2 LRO Cycle 1, Center right: Jason 2 LRO cycle 2; Lower left: J1 Entire GM; Lower right: Jason 2 Entire GM (Both LRO cycles)



A high-precision dataset, with its assessed accuracy superior to ~2 mGal, is collected on the basis of a corporation with the National Geospatial-Intelligence Agency (NGA). Over 1.4 million measurements are distributed within the northwest Atlantic Ocean bounded by (20° ~90° W, 20° ~55° N) and their observed marine gravity anomalies



	All depth	< 50 meters	>2000 meters
No. Of Observation	1409700	122108	900969
J1 Sub-cycle 1	5.36	5.25	5.13
J1 Sub-cycle 2	5.53	5.95	5.37
J1 Full GM	4.66	5.14	4.34
J2 LRO cycle 1	4.83	5.40	4.43
J2 LRO cycle 2	4.92	5.55	4.66
J2 Full GM	4.08	4.21	3.72

Marine comparison with various Jason datasets

Importance of rewind GM in case of Safeholds.

Safe-holds degrades the various comparisons with marine gravity. Comparing the Jason-2 1st and 2nd LRO cycles which encountered 39 and 60 days (40 days safe-hold plus 20 days early mission termination) exhibit 4.83 vs 4.92 mGal respectively. The numbers are also inferior to gravity derived from Jason-1 GM at 4.66 mGal. However, this GM lasted 30 days longer and only had 18 days safe-holds The impact is even larger for particularly coastal regions as also indicated in the Table 3. Safe-hold degradation becomes more significant when comparing the Jason-1 first and second Sub-cycle where the numbers are 5.36 and 5.53 mGal, respectively. The 18 days safe-hold correspond to 10% of the time of the second cycle but resulted in a degradation of roughly 5 % with degradation in coastal regions of more than 10% (from 5.25 to 5.95 mGal).

When the second sub-cycle of Jason-1 was completed the satellite naturally transferred into a subsequent 3rd sub-cycle repeating the same ground track pattern along shifted tracks. The question arises if it would be better to design future GM to "rewind" the mission to remedy significant safe-hold or to continue with the subsequent sub-cycle.

This was examined by adding data from the 3rd sub-cycle to the "safe-hold" affected 2nd sub-cycle of Jason-1. Adding 20 or even 50 days achieved an accuracy of 5.47 and 5.40 mGal, which is still inferior to the comparison from the first sub-cycle. However, the results after 50 days (nearly 1/3 of a sub-cycle) approaches the same accuracy as could have been achieved by a "mission rewind". Unfortunately Jason-1 ceased operating at this stage. A possible "mission rewind" is even more important in the coastal zone. Here the degradation from (from 5.25 to 5.95 mGal for the second cycle only improves to 5.82 and 5.77 adding altimetry from 20 and 50 additional days from sub-cycle 3.

Our conclusions

Rewinding the GM to recover mission tracks are particularly important as global marine gravity continues to increase in accuracy with more and more GM data becoming available and are integrated with the Jason altimetry

Jason-3 EoL preparation

- If the graveyard orbit of Jason-2 could be used for future Jason-3 in a way so collision risk could be avoided, we explorer the idea of moving Jason-3 into interleaved tracks with Jason-2 and bisecting the already 2-years or 4 km Jason-2 GM creating a 2 km grid after only 2 years of GM. This way re-using and building on the existing 2 years of Jason-2 GM rather than starting over with a new GM.

- We created a grid from the first 371-day cycle for Jason-2 (having data for 332 days) and the first two 179-days sub-cycles of Jason-2 (totally 340 days) to directly compare the effect of a 2-years systematically densified GM versus two separate 1-year un-coordinated GM affected by the moiré patterns (Dibarboure et al, 2012).
- The investigation showed, that the standard deviation increases from 4.08 mGal for the 2-year densified mission to 4.20 mGal for 2 years of un-coordinated GM.
- For coastal region the numbers increase significantly more from 4.21 mGal to 4.50 mGal. The difference might appear small but it is important and it should be noted that Jason-2 suffered from significant safe-holds problems during the second cycle. Hence the gain from densifying an existing GM will be significantly larger than starting all over with a new GM in a different orbit.

Summary

- Rewinding the GM to recover mission tracks are particularly important as global marine gravity continues to increase in accuracy with more and more GM data becoming available and are integrated with the Jason altimetry (e.g. from the uncontrolled GM of SARAL/AltiKa).
- Considering minimizing the effect of significant safe-holds is equally important for Mean Sea Surface determination paramount to deriving accurate sea level anomalies. Here the GM data governs the accuracy of the fine scales of the MSS. This is particularly important for future high-resolution altimetric mission like the NASA/CNES Surface Water and Ocean topography (SWOT) to be launched in 2022.
- If collision risk between Jason-2 and Jason-3 in the same graveyard orbit could be assessed and found to be controlled we explored the idea of moving Jason-3 into interleaved tracks with Jason-2 and bisecting the already 2-years or 4 km Jason-2 GM creating a 2 km grid after only 2 years of GM. This would enable a global gravity field and more importantly a global MSS with un-precedence resolution in time for the SWOT mission. If technically possible our findings strongly recommends to reuse the Jason-2 LRO orbit with Jason-3 to bisect and densify the geodetic grid in a regular way as opposed to a new GM orbit where the grids won't be aligned.