Future altimeter systems : is mesoscale observability guaranteed for operational oceanography?

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Abstract

Until recently, the exceptional longevity of T/P and GFO added to the performance of Jason and ENVISAT were hiding the risk of future data gaps.

The current missions are still performing well but they were not designed to reach the launch of Jason-2. With the current launch schedule can we guarantee a sufficient mesoscale observability for new and developing applications and operational oceanography ?

In this paper we use a probabilistic model to better assess the odds of having an observing system (multiple altimeters) accurate enough to provide the input measurements needed for NRT applications.

Approach

The lifespan probability model of a satellite is complex and driven by platform and payload design. This probability function is approximated with a simple model using recent results from AAS.

Each altimeter is given his own probability function based on his launch date, on his expected lifespan (Fig. 1). CryoSat is considered only as 50% operational on ocean (not its primary mission, payload limitation and non-repetitive ground track).

Combinatorial probabilities are then computed based on each individual probability function. Altimeters are also grouped by ground track (redundant measurements are not stacked).

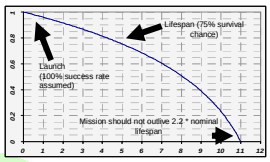

Fig 1 : Probability function used for an altimeter with a 5 year lifespan

Model validation

The probability model is validated using historical datasets. DUACS products are used to take into account actual coverage on ocean (Fig. 2) : platform/payload events, science data loss, bad data edited out…

The agreement between the model prediction and the reality observed on actual data is good (Fig. 3) whereas the theoretical coverage (not taking into data loss) is very optimistic.

The comparison shows two significant differences : the post-launch anomalies on GFO (unusable until 2000), and the unexpected longevity of T/P.

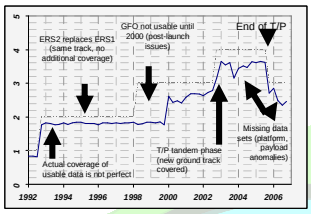

Fig 2 : Number of altimeters in operations expected by the probabilistic model (bottom) and actually used by SSALTO/DUACS (top, solid line). Number of altimeters that DUACS would have used with an ideal coverage (top, dashed).

In both cases, the event is against the base probability assumption given to the satellite : 100% success rate at launch, and 2.2 * lifespan max. Better probability models can be used: boolean branching and better lifespan characterization…

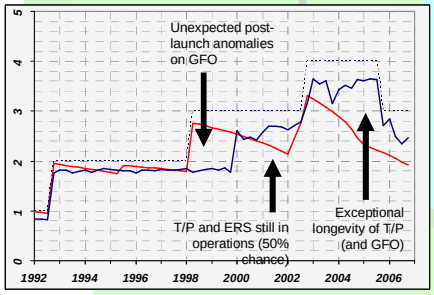

Fig 3 : Number of altimeters in operations expected by the probabilistic model (red) and actually used by SSALTO/DUACS (blue, solid). Number of altimeters that DUACS would have been used with an ideal coverage (blue, dashed).

Will altimetry provide the input needed by NRT applications?

A two satellite sampling is acknowledged as the minimum needed for offline mesoscale applications, and three satellites is the minimum needed for near real time (NRT) applications and operational oceanography (see poster from Pascal et al).

The probability model is used to assess the odds of having two or three satellites in operations in the future (Fig. 4) : the **minimum** needed to observe and to monitor mesoscale structures in delayed time or near real time respectively.

As far as offline observability is concerned, the likelihood of having two operational altimeters flying on different ground tracks is good (>60%) after the Jason-2 launch.

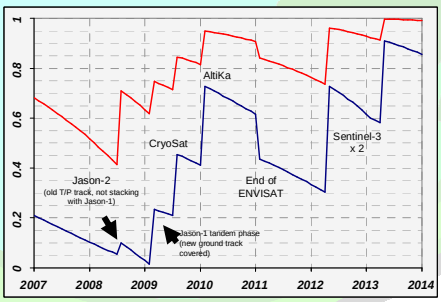

Fig 4 : Probability to have two (red) or three (blue) altimeters in operations with the current launch schedule and a Jason-1 tandem mission after six months of expertise phase for Jason-2. The red line corresponds to the minimum needed for offline (delayed time) mesoscale observation, and the blue line to the minimum needed for near real time applications and operational oceanography.

However the odds of meeting the minimum near real time requirements for applications and operational oceanography are very poor with less than 25% chances until CryoSat, and less than 10% in 2008. Despite the 2008/2010 launches, the odds fall down to 30% after the scheduled end of ENVISAT in 2010, and until both Sentinel-3 are operational.

These results might even be optimistic since future altimeters are assumed to be operational just after launch (no expertise or Cal/Val phase, no GFO-like issue).

It is ironically when operational oceanography and NRT applications start to be fruitful that NRT altimeter data may be lacking.

Improving the odds

Considering the cost and effort involved in a new altimeter, it might prove useful to optimize launch schedule and choices/tradeoffs in terms of mission operation. The probabilistic model was used to explore alternate scenarios and to assess the impact of various decisions on the minimum observability needed for Near Real Time applications and operational oceanography.

As an illustration, shifting Jason-1 on a different orbit (tandem phase, similar to the Jason/TP phase in 2003/2005) would improve the NRT odds by 20% (Fig. 5). The cross-calibration of both Jasons is mandatory, but if the tandem phase does not start six months after launch, the odds of getting the minimum NRT data reach 0%.

Similarly, an additional 20% chances can be gained if CryoSat data are fully exploited (Fig. 6) with a complete coverage on ocean, and better geophysical corrections/references : improved MSS to balance out the non-repetitive ground track, ionosphere correction based on the merging of GPS and Doris data (onboard all altimeter platforms) and wet troposphere correction based on the multi-mission merging of external radiometer data…

As far as new missions and new instruments are concerned, it is important to schedule Jason-3 as soon as possible to consolidate the NRT data sampling (Fig. 7), and before the first S3 launch a Wide Swath Altimeter would prove precious even with very pessimistic error budgets (Fig. 8).

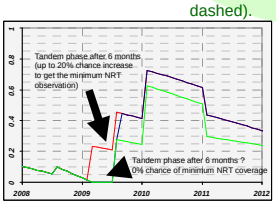

Fig 5 : Probability to have the minimum NRT observability without a Jason-1 tandem mission (green), or with a Jason-1 tandem phase 6 months (red) or 1 year (blue) after the launch of Jason-2

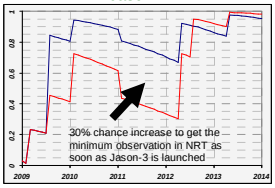

Fig 7 : Probability to have the minimum NRT observability with a Jason-3 launch in mid 2012 (red) or in mid 2009 (blue).

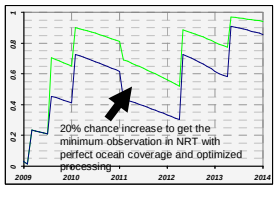

Fig 6 : Probability to have the minimum NRT observability with opportunistic ocean data from CryoSat (blue) and with perfect ocean coverage and improved geophysical corrections (green).

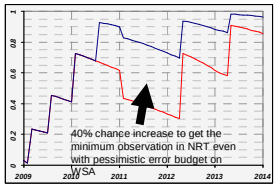

Fig 8 : Probability to have the minimum NRT observability with (blue) or without (red) a wide swath altimeter launched in 2010