Quality of real time altimeter maps: impact of data delivery delay

A.Pascual
- IMEDEA(CSIC-UIB)

G.Dibarboure
C.Boone
G.Larnicol
- CLS

Abstract

The timeliness of satellite altimeter measurements has a significant impact on their value for operational oceanography. In this work, we use an OSE (observing system experiment) approach to assess the quality of near real time (NRT) altimeter products, a key issue for a correct monitoring and modeling of the ocean state.

In a nominal NRT situation, at least 3 altimeters are needed to get the observing capability of 2 altimeters in offline products (delayed time).

The analysis is extended with an assessment of the NRT error increase when altimeter flows are not delivered normally. After a few days of anomaly, is a three altimeter NRT observing system still able to meet the minimum requirement for mesoscale observability?

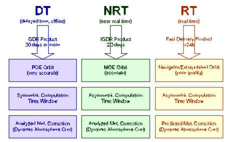

Figure 1: Delivery delay and precision tradeoff on altimeter product types

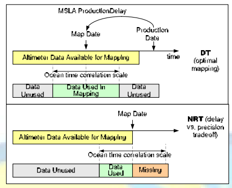

Figure 2: Time window centering in the mapping process. Difference between optimal mapping in DT and precision/delay tradeoff in NRT

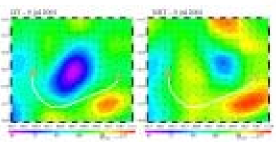

Figure 3: Comparison of altimetry and drifter data in a cyclonic eddy in the Brazil-Malvinas Confluence Region. The white line shows the trajectory followed by a surface float between 4 July 2003 (A) and 13 July 2003 (B). The vectors correspond to the absolute velocity field (geostrophy + Ekman) and the background color field is the SLA+MDT (in cm) on 9 July 2003.
Left : **delayed time products.**
Right : **real time products.**

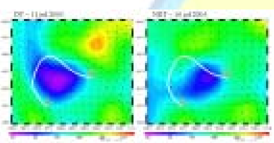

Figure 4: As in Fig. 3 but one week later. Both vectors and background color field correspond to 16 July 2003. The white line shows the trajectory followed by the surface float between 11 July 2003 (A) and 21 July 2003 (B).

Overview and objectives

There are three categories of altimeter products (Fig. 1). The DT or GDR products benefit from the best accuracy, but the delay is not compatible with the requirements of operational oceanography. NRT products are used operationally but they involve additional sources of errors such as a less accurate orbit (MOE).

The NRT mapping process is not optimal due to the delay vs precision tradeoff. To produce maps of SLA in near real time, one does not have access to altimeter measurement in the “map future” like in optimal DT mapping (Fig. 2). The objective of this work is to assess and to understand the additional NRT error, both in nominal and in degraded configurations.

In a first step, we generate a delayed time data set used as a reference. A near real time data set is then simulated using a realistic orbit error and consistent asymmetric time windows (Fig. 2).

Then we compare the accuracy of fast delivery products with respect to “optimal” delayed time data using tide gauge and drifter data.

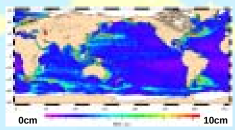

Figure 5 : RMS of the differences between delayed and real time SLA (both are combining 4 altimeters)

	2 missions	4 missions
Delayed Time	36.7	29.7
Near Real Time	45.2	37.1

Figure 6: Mean square differences between tide gauges and altimeter sea level. Units are in % of the tide gauge variance

	Delayed Time		*Real Time*	
	2 missions	4 missions	2 missions	4 missions
U	26.6	24.2	31.0	26.9
V	33.1	28.1	41.2	33.4

Figure 7: Mean square differences between drifter and altimeter velocities. Units are in % of the drifter variance

Comparison with in-situ data

The NRT and DT datasets are compared to assess the mesoscale signal missed by NRT processing. The information lost in a non-centered mapping is significant with 5 to 10 cm RMS (Fig. 5).

Both data sets are compared with in-situ data, either locally (individual measurements) or globally (statistical results).

Altimeter measurements unavailable in Near Real Time contain precious information that allow DT processing to build a SLA map significantly more accurate than in NRT.

Important mesoscale structures are sometimes missed by the NRT mapping whereas the DT mapping benefit from local measurements able to observe the eddy (Fig. 3 and Fig. 4).

Statistically speaking, the additional error in NRT is large with up to 25% more differences with in-situ data than on DT maps (Fig. 6). A four satellite NRT dataset is roughly as accurate as a two satellite DT dataset (Fig. 7).

If two satellites are acknowledged as the bare minimum needed to observe mesoscale structures on offline products, three or even four satellites are needed to do the same in NRT.

Performance loss with late IGDR delivery

The analysis is extended with an assessment of the NRT error increase when altimeter flows cannot be delivered normally. Simulated NRT maps are computed as if the input IGDR were delayed (missing, platform anomaly…).

The quality of simulated NRT maps quickly deteriorates when altimeter data are delayed or missing. The comparison of “optimal” DT maps with degraded NRT maps (as a function of the number of days of delivery delay) shows a linear trend. Results are the same for all areas and only the base variance is different (Fig. 8).

The linear trend is used to define a NRT performance indicator. The RMS of the DT-NRT difference (additional NRT error) is normalized by the best and the poorest NRT results one could obtain in a nominal scenario (Fig. 9). This indicator shows how good the NRT configuration is, and how sensitive to data gaps and delays it can be.

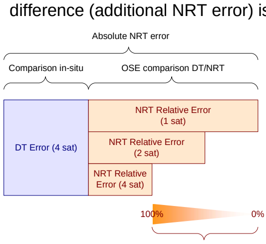

Figure 9: NRT performance indicator obtained from the DT-NRT comparison and normalized by the best/worst NRT configuration.

The indicator shows similar results for all areas studied (Fig. 10). For a two satellite configuration, there is a 5% error increase per day of missing data, and only 4% for a three satellite configuration. Not only is a three satellite configuration better in a nominal case, but it is also more resilient to data gaps and delays.

As an illustration, after six days of missing data (stacked over all missions) a 3-satellite configuration becomes hardly more accurate (in NRT) than a 2-satellite configuration in nominal status.
Similarly on a 2-satellite configuration, 50% of the improvement from the second altimeter is lost when 4 days of IGDR are missing or delayed.

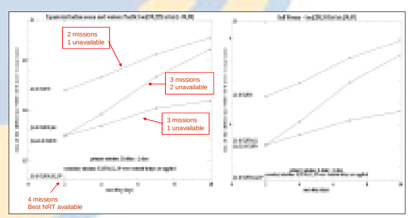

Figure 8: RMS of the NRT-DT differences as a function of the NRT delivery delay in the Equatorial Indian (left) and in the Gulf Stream (right). When IGDR data are temporary unavailable, the NRT maps are unavailable to reproduce the signal in « optimal » DT maps.

Conversely, these results show that being able to process Real Time altimeter products (Jason OSDR, ENVISAT FDMar…) with an IGDR-like accuracy could improve the NRT accuracy by up to 25%. This would improve the NRT maps in a nominal case, and it would allow the system to resume a nominal accuracy 48h faster.

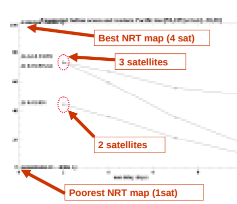

Figure 10: NRT indicator (0 to 100%) as a function of the IGDR delivery delay in the Equatorial Indian (left) and in the Gulf Stream (right). Assessing the performance loss when IGDR data are temporary unavailable.