Value of the Jason-1 geodetic phase to study rapid oceanic changes

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Abstract

There are 1200 overlap events where Jason-1 GM and Jason-2 tracks align perfectly (less than their altimeter footprint radius) over thousands of kilometers. Both altimeters are also separated by 0 to 10 days (less than one Jason-2 repeat cycle).

Our first statistical analysis of these overlap events highlights their value to study rapid oceanic variability.

Examples

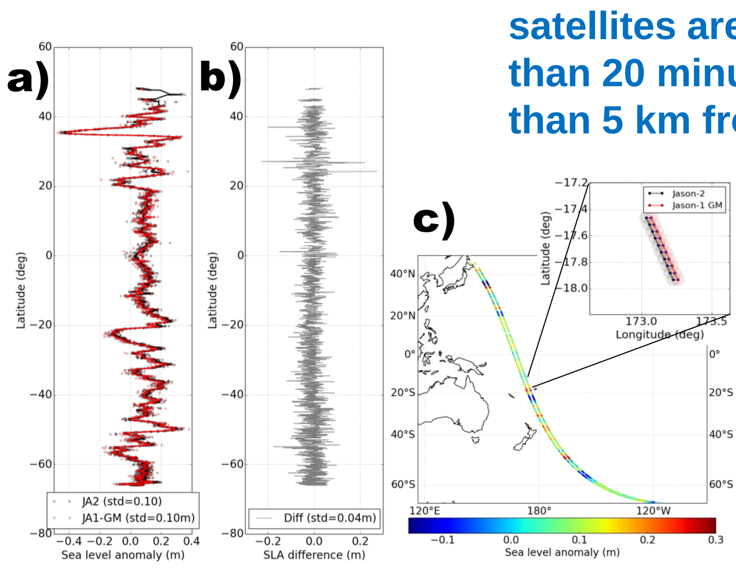


Fig 1 : Comparison of Jason-2 and Jason-1 GM when both satellites are separated by less than 20 minutes and flying less than 5 km from one another

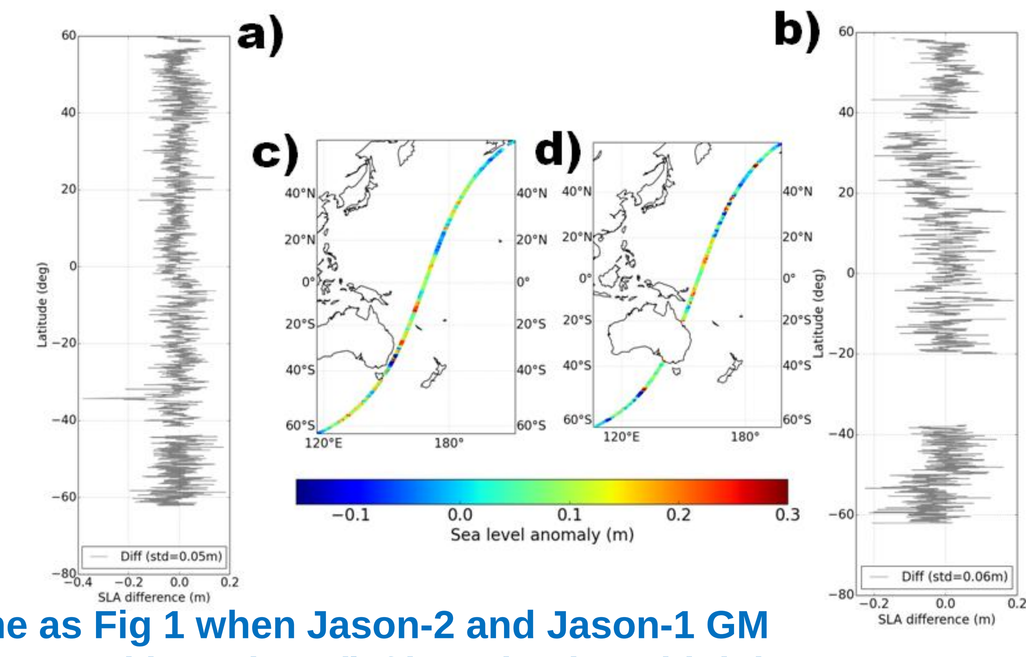


Fig 2 : Same as Fig 1 when Jason-2 and Jason-1 GM are separated by 2 days (left), and 5 days (right)

Distribution of overlap events

Fig 3a shows the longitude of the equator crossing of Jason-2 (red) and Jason-1 GM (blue) throughout the 40 first days of the Jason-1 GM phase. Overlap events are highlighted with black dots and lines linking the tracks of each altimeter.

Fig 3b shows the distribution of the time difference between Jason-1 and Jason-2 measurements during overlap events. **Fig 3c** is similar to panel (b) but split into 4 subsequent periods of 90 days (~seasons).

Fig 3d shows the difference in solar time between Jason-1 GM and Jason-2, as a function of the time difference, and the limit of overlap events for most tidal studies

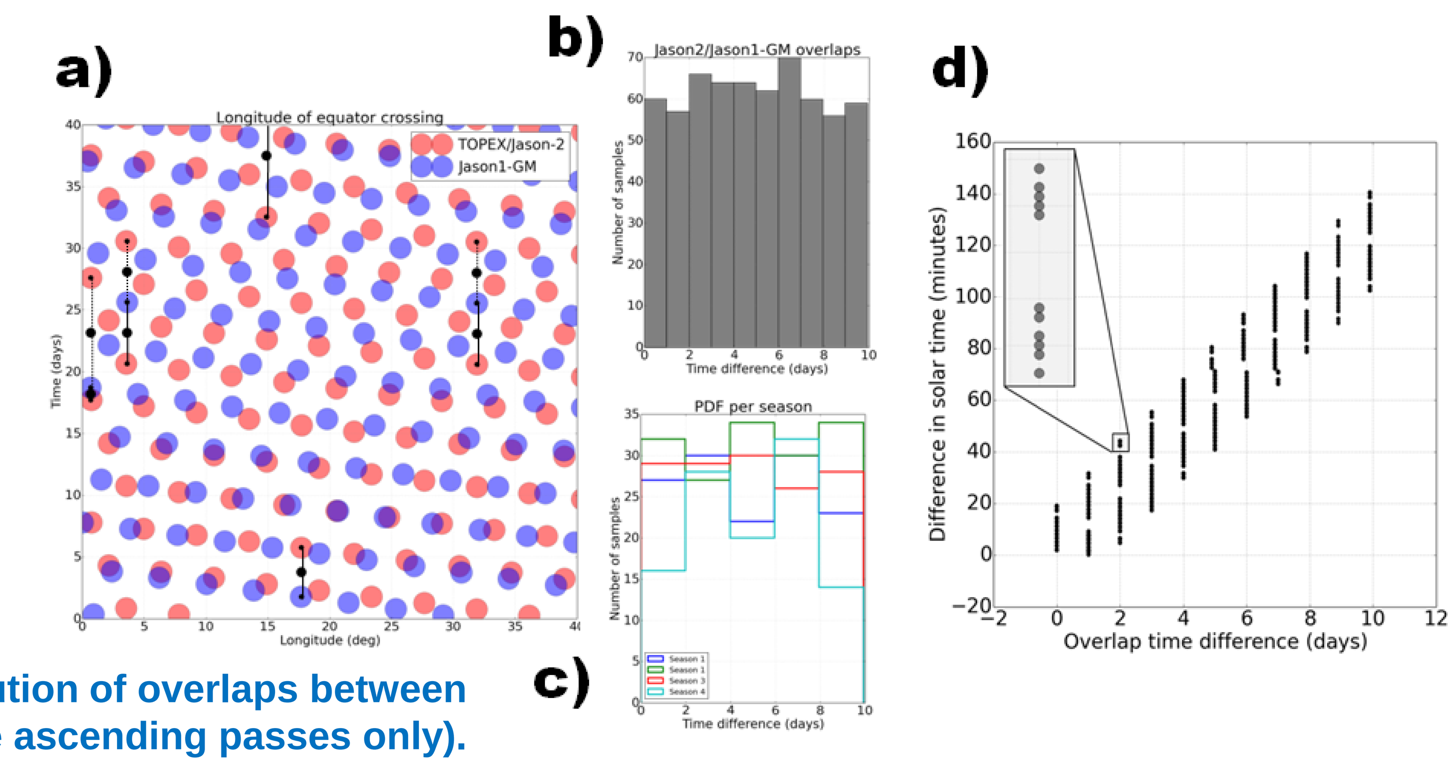


Fig 3: Overview of the space/time distribution of overlaps between Jason-2 and Jason-1 GM (here ascending passes only).

Spatial properties

For 0-day overlaps, the spectrum of **Fig 4** is almost flat and dominated by instrument noise. Difference spectra from 1-day (purple) to 5-day (cyan) show a rapid increase of the PSD for wavelengths > 60-70 km. This analysis is primarily limited by the 1Hz noise floor of Jason-class altimetry.

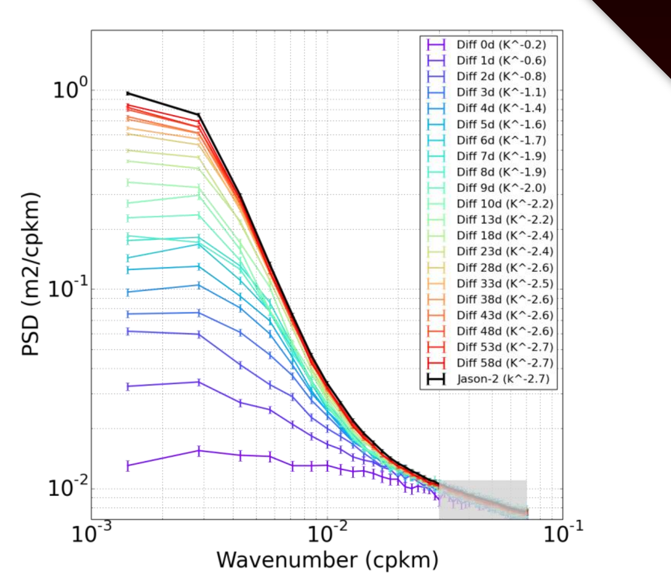


Fig 4: Mean global spectrum of Jason-2 - Jason1GM for 0-day to 60-day (purple to red) overlaps. The Jason-2 PSD is in black.

The 0-day autocorrelation function of **Fig 5** has a Dirac shape expected on a difference dominated by white noise. In contrast, 1-day and beyond exhibit typical SSHA auto-correlations with a small negative lobe and zero-crossing values ranging from 60 km to slightly more than 100 km (global ocean).

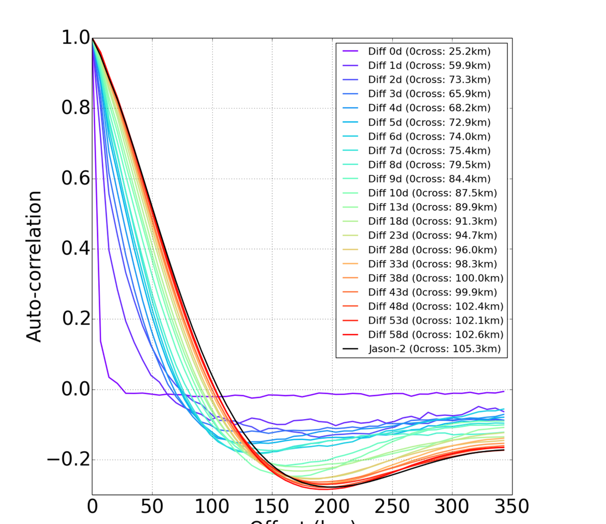


Fig 5: Mean global auto-correlation with zero-crossing values for 0-day to 60-day (purple to red) overlaps. The Jason-2 auto-correlation is in black.

As soon as the time difference is not zero, various regions start to emerge in **Fig 6**. The influence of rapid mesoscale is clearly dominating the distribution. By 3-5 days, energy is also apparent in the Western Tropical Pacific and Intertropical convergence zones.

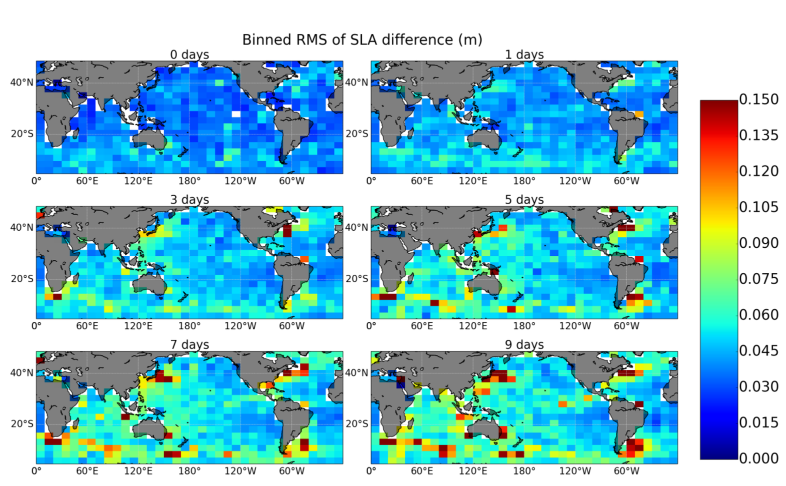


Fig 6: Binned RMS of Jason-1 GM / Jason-2 differences during overlap events ranging from 0-day (upper left) to 9-days (lower right)

Temporal properties

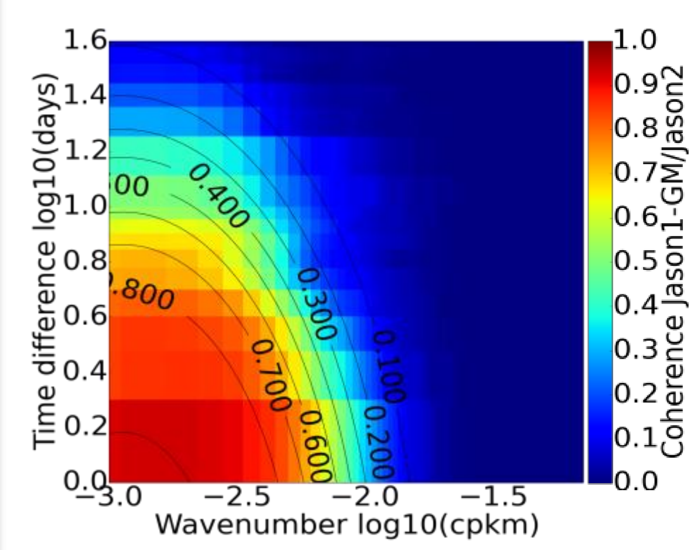


Fig 7: Coherence between Jason-2 and Jason-1 GM (coloured back-ground) for 0-day to 60-day (purple to red) overlaps and superimposed with an analytical model (black lines)

Fig 7 shows the synthetic 2D space-time coherence as a colored background. The coherence is high for short time differences and long wavelengths. It decreases for higher wave-numbers as the incoherent noise of the altimeters becomes dominant, and it decreases for longer periods because of ocean variability.

An analytical model (black lines) model yields typical values of [21 days, 300 km] and [10 days, 150 km] for the key coherence level of 0.25.

Fig 8 shows a linear increase of the variance in most regions, and panel b illustrates that the variance of the Jason difference becomes asymptotically flat as dt increases beyond 10 days. This happens more rapidly in some regions (Mediterranean Sea, Gulf Stream, Kuroshio) than others (North-East Pacific or Tropical Pacific). An analytical model yields e-folding radii ranging from 19 to 30 days.

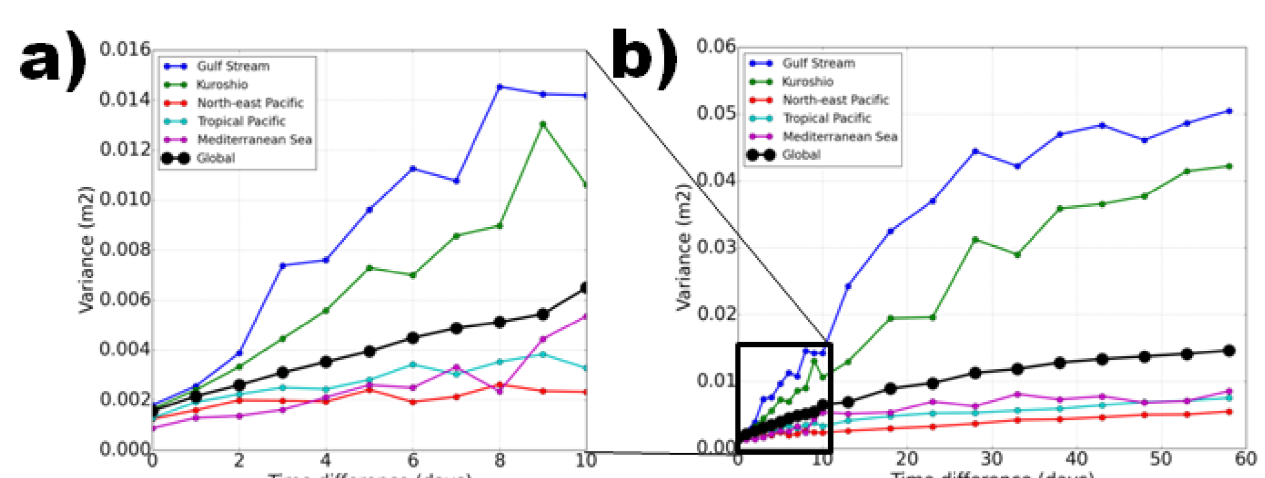


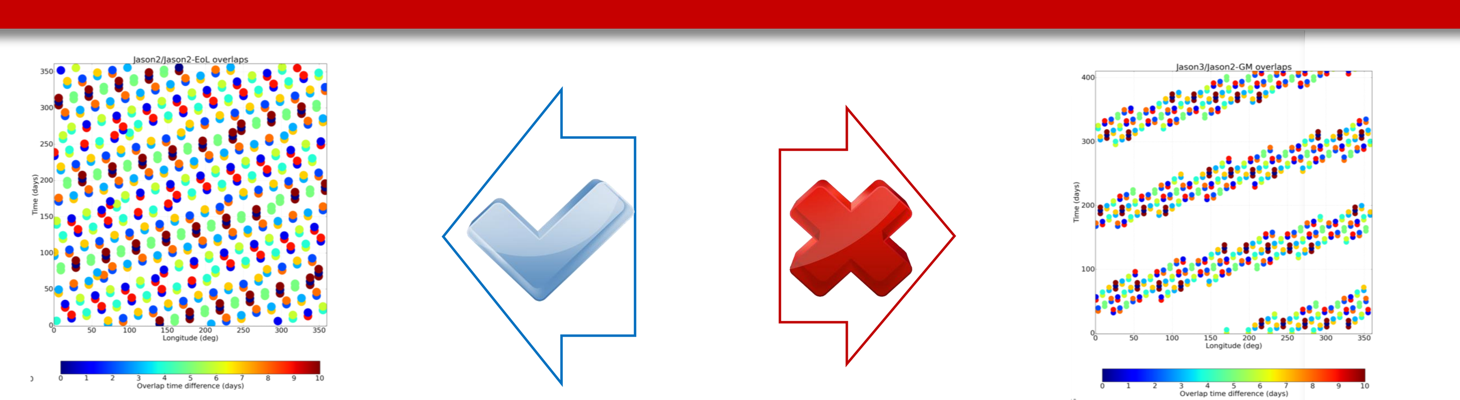
Fig 8: Evolution of the global (black) or regional (colors) variance of the Jason-2 / Jason-1 GM difference as a function of the time distance between both samples. Panel (a) shows the result for 0-day to 10-days and panel (b) for 0-day to 60-days.

Consequences for Jason-2

If Jason-2 must be moved to a geodetic orbit, it will collect overlap samples when it flies over the Jason-3 tracks. **Fig 9** shows that if the Jason-2 GM orbit is not well chosen, overlap events could be aggregated in certain regions/periods, thus skewing the Jason-2GM/Jason-3 overlap dataset.

One can maximize the quality of this dataset independently from other criteria used to select the geodetic orbit of Jason-1 (mesoscale and geodetic sampling) so we screened 20,000 orbits to identify good options for Jason-2.

One of the best candidate is approximately 35 km above the TOPEX orbit (12+247/401 revolutions per nodal day).



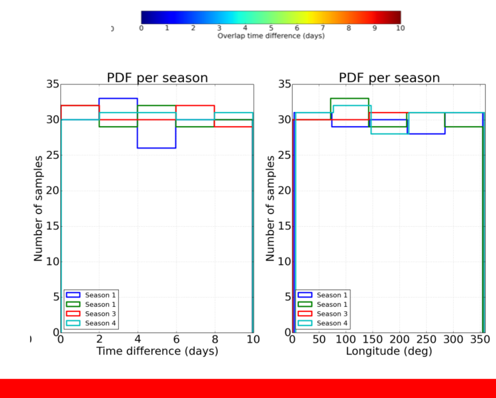
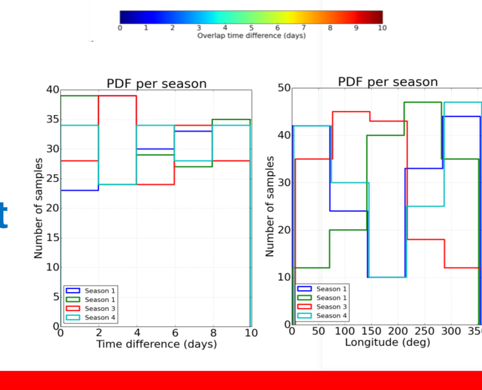


Fig9: Distribution of overlap events between Jason-3 and Jason-2 GM for a good orbit option (left) and a bad orbit option (right)



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