AVISO

10

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SARAL

Special SARAL/AltiKa Issue

SARAL/AltiKa: A Ka Band Altimetric Mission

Prepared by Jacques Verron — CNRS/LGGE Grenoble

This special issue of AVISO Newsletter gives a thorough and extremely positive presentation of the first calibration/validation investigations and of the very first scientific investigations that have been undertaken with SARAL/AltiKa data.

The SARAL/AltiKa satellite mission is an India-France ISRO-CNES joint project. The satellite was put into orbit by a PSLV vehicle supplied by ISRO, and launched from the ISRO Sriharikota launch base, on Feb. 25, 2013. The SARAL (Satellite for ARgos and ALtika) payload consists of an ARGOS instrument and an altimetry payload provided by CNES, including the AltiKa radiometer-altimeter.

SARAL/AltiKa is intended to be a gap filler mission between the RA-2 carried on board Envisat and Sentinel-3. As such, SARAL/AltiKa flies on the same orbit as Envisat. The special feature of SARAL/AltiKa is that it is based on a wideband Ka-band altimeter (35.75 GHz, 500 MHz), which is the first satellite altimeter dedicated to oceanography to operate at such a high frequency. The AltiKa instrument consists of a Ka-band altimeter and an embedded dual frequency radiometer. The enhanced bandwidth provided by the single frequency Ka-band altimeter leads to a better vertical resolution. The spatial resolution is also improved, thanks to the Ka-band's smaller footprint.

Credits CNES/ Mira production

Results exceed expectations

The quality of the earliest data is indisputable, which is highly satisfying and exceeds expectations and the initial mission requirements. SARAL/AltiKa was seen as a "medium accuracy, complementary mission" with regard to the Jason "reference mission". First results are at least in line with Jason-2. Also, the quality of SARAL/AltiKa data in terms of accuracy, data latency and availability has made it possible to make the data available rapidly, leading especially to efficient integration in several operational systems. The known effect of rain on the Ka-band has to raised some uncertainty regarding the full availability of data in some regions. This proved to be much less constraining than expected. On the other hand, improved ability in coastal areas is confirmed and improved resolution in general is validated so far. Initial data from other domains of application such as the monitoring of inland waters and ice sheets have also been examined, with quite satisfactory findings so far.

I personally found a real enthusiasm talking to the people who have looked at the first SARAL/AltiKa data. I hope that reading this NewsLetter will also stimulate your interest for this satellite mission.

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- Jacques Verron (in French, 8'43'')
- John Lillibridge (6'54'')
- Phil Callahan (10'26'')
- Pascal Bonnefond(in French , 4'57'')
- Suchandra Aich Bhowmick (6'43")
- James Richman (4'32'')
- Lotfi Aouf (in French , 5'51'')
- Stéphane Calmant (in French , 9'36'')

Events

9 - 13 December 2013:	AGU San Francisco Fall Meeting, San Francisco, CA, USA
23 - 28 February 2014:	AGU Ocean Sciences, Honolulu, Hawaii, USA
21 - 24 January 2014:	GODAE, Puerto Rico
22 - 24 April, 2014:	SARAL International Science and Applications Meeting, SAC-Ahmedabad, India
27 April - 2 May 2014:	EGU, Vienna, Austria
13 - 18 July 2014:	IGARSS, Québec, Canada
28 - 31 October 2014:	OSTST, Lake Constance, Germany (IDS and SARAL/Altika workshop on October, 27th)
15 - 19 December 2014:	AGU, San Francisco, USA

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Aviso, 8-10 rue Hermès
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Performance of SARAL/AltiKa GDR data

Prepared by Sabine Philipps, Pierre Prandi and Michaël Ablain — CLS Toulouse, France

This chapter provides a quick overview of SARAL/AltiKa data quality. Thanks to CNES SALP/Calval tools, measurements are carefully edited and missing data identified. Furthermore, sea level anomaly (SLA) is compared between SARAL/Altika and Jason-2 and performances at crossover points are analyzed.

The ISRO-CNES mission SARAL/AltiKa was successfully launched on February 25th 2013, and has been on its operational orbit since March 13th. During the first few months, it was not on exactly the same ground track as Envisat (roughly 2 km difference at pass extremities). After inclination maneuvers, SARAL reached the same ground track as Envisat on October 7th. Since the beginning of the mission, SARAL/AltiKa data have been analyzed and monitored in order to assess the quality of SARAL/AltiKa products. Cycle by cycle reports are available on the AVISO web-page.

Missing and edited data

SARAL/AltiKa is the first altimeter using the Ka-band frequency. The advantage of this higher frequency is a reduced footprint that leads to a better spatial resolution. Nevertheless, this frequency is also more sensitive to rainy and cloudy conditions. More missing data were therefore expected than for Ku-band altimeters.

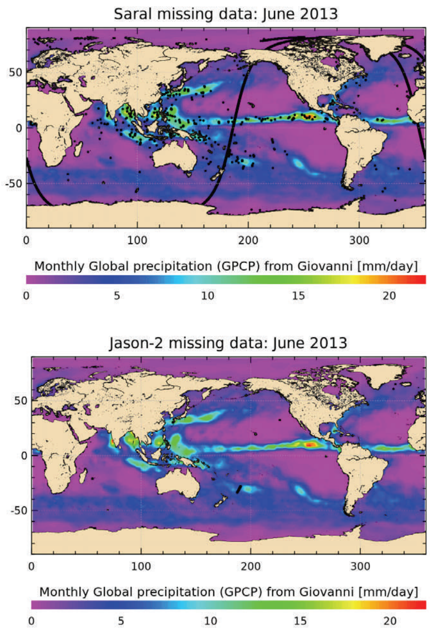


Figure 1: Missing data of Saral (top) and Jason-2 (bottom) for June 2013 superposed with monthly global precipitation (June 2013 from Giovanni website). (Credits CNES/CLS)

Though SARAL has indeed more missing data over oceans than Jason-2, especially in regions with rain (as shown on Figure 1), the amount of data loss due to rain events is very small and less than originally expected. The availability of ocean data is around 99.4%, which largely exceed the mission requirements of 95% of data availability over ocean.

Using standard editing criteria "an ice_flag", as well as thresholds for several other parameters, as explained in the SARAL/AltiKa handbook, about 20.6% of ocean data are edited, varying with the season. Most of them (18.2% of ocean data, varying seasonally with ice coverage) are edited by the ice_flag. About 2.6% of the ocean data without ice are edited by threshold criteria, which is less than for Jason-2 (around 3.5%).

Noise levels

The specification of the 1 Hz noise level for range data (with significant wave height of 2m) is 1.5 cm. Measurements on ground (during the altimeter acceptance tests) obtained a value of 0.9 cm. Figure 2 shows the mean of the range_rms parameter (40 Hz for SARAL, 20 Hz for Jason-1/2) for valid 1 Hz data as a function of the significant wave height. For significant wave height of 2 m, this yields to:

- 5.1 cm for SARAL (40 Hz) → 0.8 cm for 1 Hz
- 7.2 cm for Jason-1/2 (20 Hz) → 1.6 cm for 1 Hz

The SLA power density spectrum of 40/20 Hz data (Figure 3) shows that the noise level of SARAL 40 Hz data is 5.6 cm which is lower than for 20 Hz Jason-2 data (7.7 cm). The spectral hump is still present on the SARAL/AltiKa spectrum, but shifted to shorter scales (mainly due to the smaller waveform footprint). Therefore, Saral/AltiKa is able to observe smaller ocean scales (down to 50 km) than Jason-2 (~100 km)

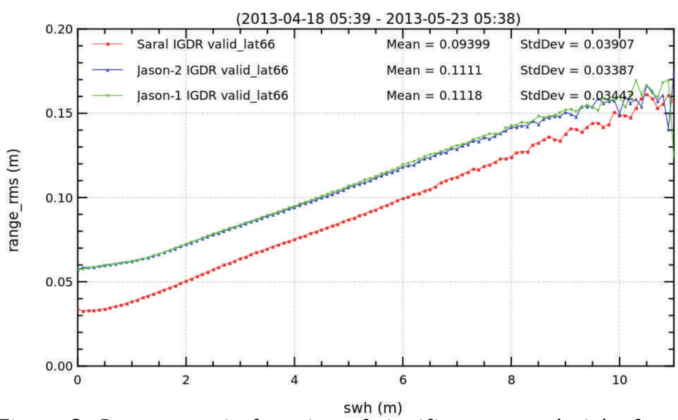


Figure 2: Range_rms in function of significant wave height for Saral and Jason-1/2. (Credits CNES/CLS)

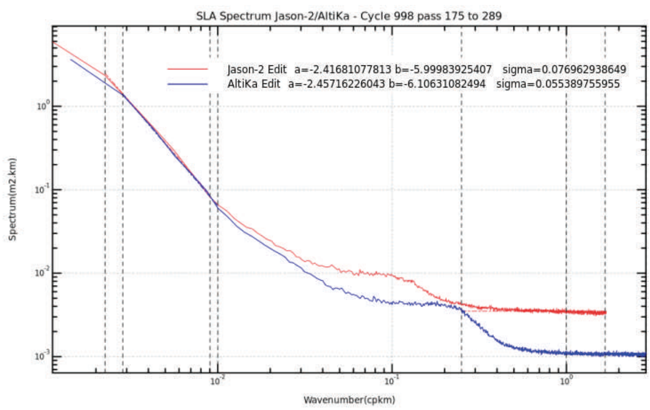


Figure 3: Spectrum (orbit - range - mss) of 40 Hz for Saral (20 Hz data for Jason-2). (Credits CNES/CLS)

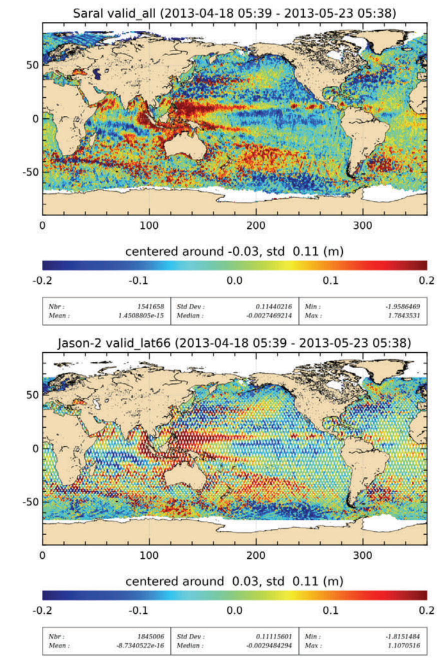


Figure 4: Maps of sea level anomaly for Saral (top) and Jason-2 (bottom) Igdr for Saral cycle 2 using model wet troposphere correction. (Credits

Sea level anomaly

Maps of sea level anomaly shows very similar structures for SARAL/AltiKa and Jason-2 (see Figure 4). Standard deviations of SLA are similar for both missions.

Performance at crossover points

The analyses presented below are performed over the first 5 cycles of SARAL/AltiKa using GDR products. For comparison, Jason-2 GDR data are shown over the same period. The map of SSH mean ascending/descending differences at crossovers should ideally by close to zero. Geographically correlated patterns on such maps indicate systematic differences between ascending and descending passes. This can indicate either problems in the orbit computation or with geophysical corrections. Comparing the maps of mean SSH differences over roughly 6 months of data for SARAL/AltiKa and Jason-2 (Figure 5) shows that there are no major differences between the two missions, even though SARAL/AltiKa is still in the verification phase and several algorithms need to be accurately tuned (radiometer wet tropospheric correction, sea state bias, and others). Nevertheless it is clear that the amplitude of the differences is smaller for Jason-2 than for SARAL/AltiKa. The Jason-2 map shows large scale geographically correlated patterns (positive signal in the North Pacific and the Indian Ocean, negative signal in the South Pacific and most of the Atlantic), which have small amplitudes (generally less than 1 cm). This large-scale pattern is very likely related to orbit computation. The map of SARAL/AltiKa SSH differences at crossovers shows generally negative values, except for:

- very high latitudes, especially east of Greenland,
- a patch in the southern Pacific and in the Gulf of Alaska.

The map of multi-mission crossover differences (JA2-SRL) shows regional structures of about ±2 cm. There is a strip of positive difference of about 2 cm around 50° S, a region with generally high significant wave height. This difference is very likely due to differences in sea state bias, as SARAL/AltiKa's sea state bias is not yet tuned, but set to 3.5% of Significant Wave Height (SWH) value. Otherwise large scale differences are observable (positive difference in the Atlantic Ocean and negative difference in the Pacific Ocean), which may be related to differences in orbit computation.

The global mean sea level anomaly of SARAL/AltiKa is about 6.5 cm lower than for Jason-2, when using model wet tropospheric correction (see Figure 6). This difference remains relatively stable. When using radiometer wet tropospheric correction, a drift appeared over the last couple of months. This drift in the 37 GHz brightness temperature was related to saturation of the hot calibration. The saturation of the hot calibration was corrected on 22 October 2013 by modifying the onboard radiometer database values.

As the altimeter specifications are better for SARAL/AltiKa than for

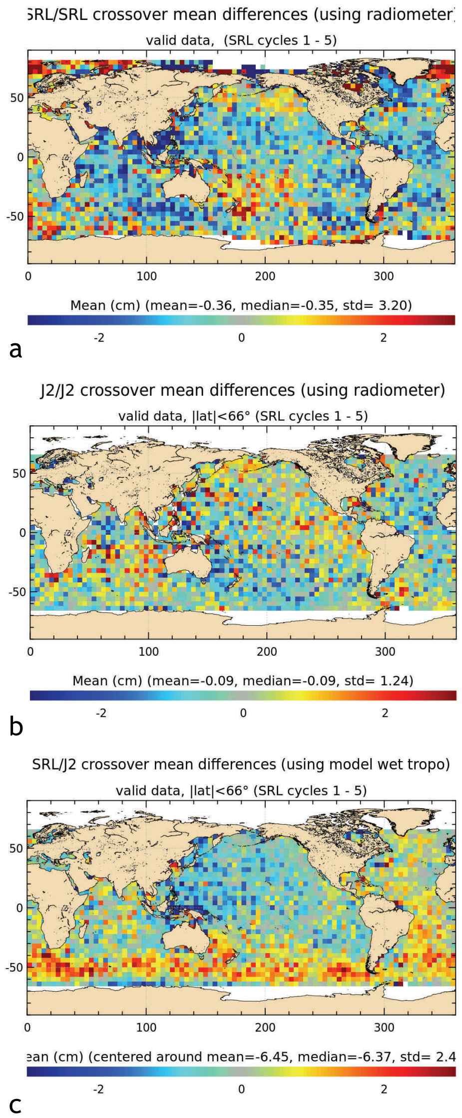


Figure 5: Maps of SSH crossover differences for Saral/Altika (a) and Jason-2 (b) using radiometer wet troposphere correction. Map of SSH differences at multi-mission crossovers (JA2 – SRL) on (c). (Credits CNES/CLS)

Jason-2 (smaller footprint, 40 Hz elementary data instead of 20 Hz, higher vertical resolution) the altimeter noise is lower (as indicated by the power spectrum in Figure 3). It could be expected that SARAL/AltiKa also performs better at crossover points than Jason-2. This is the case when interpolating the data on the positions of the crossover points by spline without taking into account the noise on the range, and when using the model wet tropospheric correction for both missions. Nevertheless the range noise (derived from the power spectrum of 1 Hz data) is generally taken into account when computing crossover points. In this case, the performance of Jason-2 is currently better. But it should be borne in mind that sea state bias for SARAL/AltiKa is currently 3.5% of the SWH value; using a dedicated sea state bias model (non-parametric or hybrid model) will significantly reduce the standard deviation of SSH differences at crossover points. When using a geographical selection (Figure 7) and the model wet tropospheric correction, SARAL/AltiKa and Jason-2 show equivalent performances. Using the radiometer wet tropospheric correction for Jason-2 shows a clear improvement concerning statistics of crossover points (and therefore concerning mesoscale results), while the impact is much lower for SARAL/AltiKa due to radiometer wet tropospheric correction retrieval algorithms not yet having been fully tuned.

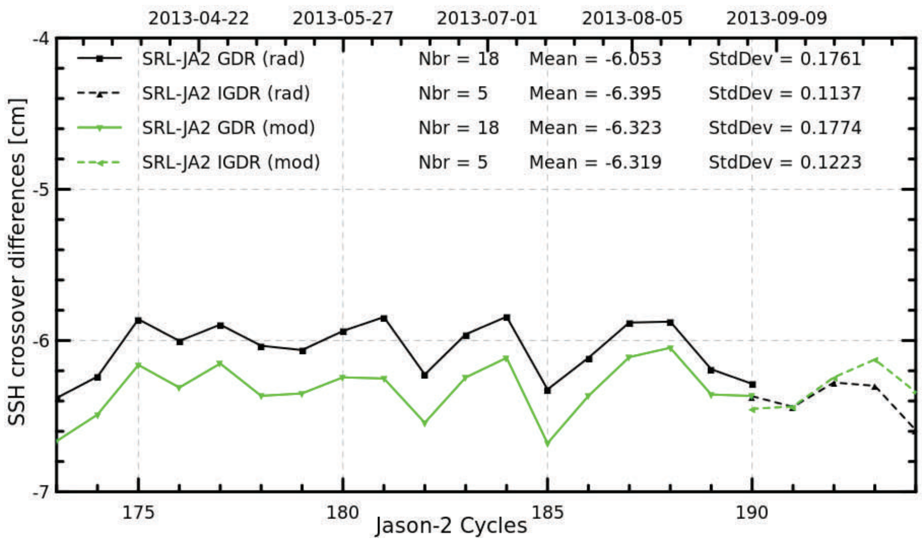


Figure 6: Monitoring of SSH differences of multi-mission crossover points (JA2-SRL) using either radiometer (black) or model (green) wet troposphere correction. (Credits CNES/CLS)

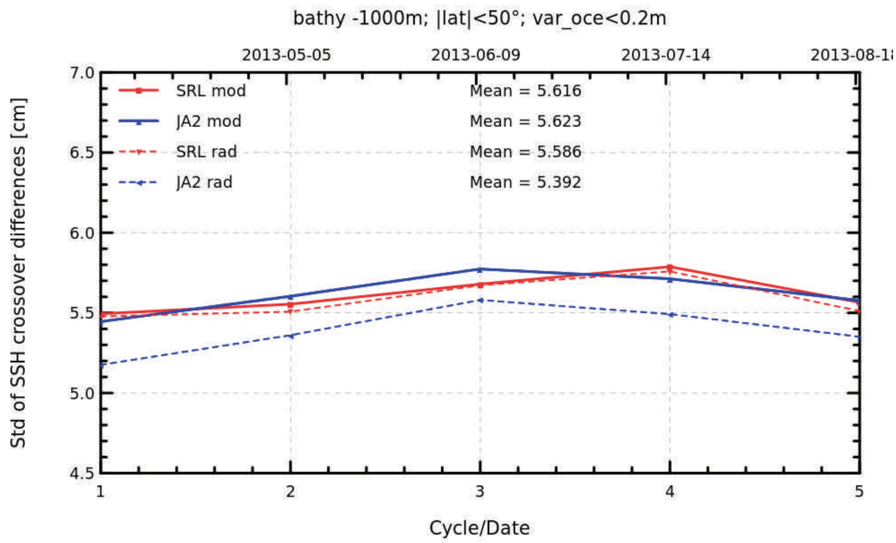


Figure 7: Cycle per cycle monitoring of standard deviation of ascending/descending SSH differences at crossover points. Geographical selections are used. (Credits CNES/CLS)

Acknowledgements: Analyses used in this [study/paper/presentation] were produced with the Giovanni online data system, developed and maintained by the NASA GES DISC

Absolute Calibration of SARAL/AltiKa in Corsica

Prepared by Pascal Bonnefond[1], Pierre Exertier[1], Olivier Laurain[1], Amandine Guillot[2] , Thierry Guinle[2] , Nicolas Picot[2]
[1] OCA/Geoazur Sophia-Antipolis, France - [2] CNES Toulouse, France

The Corsica site was established in 1996 to perform altimeter calibration of TOPEX/Poseidon and then of its successors Jason-1 and Jason-2. In 2005, it was decided to develop another location close to Ajaccio, to be able to perform the calibration first of Envisat and now of SARAL/AltiKa. Due to the size of Corsica (not a particularly small island), the altimeter measurement system (range and corrections) can be contaminated by land. The Corsica calibration process site is designed for such a study, because we correct for the geoid slope (Bonnefond et al., 2013). Figure 1 shows that the SARAL/AltiKa waveforms, and as a consequence the Sea Surface Height (SSH), are not clearly affected by land contamination up to ~3 km from the coast. Moreover, thanks to the lower noise level of the altimeter, it is possible to see that the first part of the signal, being protected by the Sanguinaires Islands (latitude > 41.85°), has a lower standard deviation due to the lower sea state than in the open sea; global standard deviation is also very low (28 mm) compared to typical Jason-2 deviation (~50-60 mm). Figure 2 illustrates the way the land contamination affects all the available cycles and compares it to Envisat over the whole mission. The huge variations observed on Envisat are clearly reduced for SARAL/AltiKa and good data can be exploited from close to the coast where Envisat had none (within 7 km of the coast).

The SARAL/AltiKa absolute bias computed from GPS sea level measurements (using a zodiac boat) is -67 ±7 mm. Moreover the time series shows a very low standard deviation (14 mm) compared to typical Jason-2 deviation (~35 mm), illustrating the high precision and stability of the altimeter.

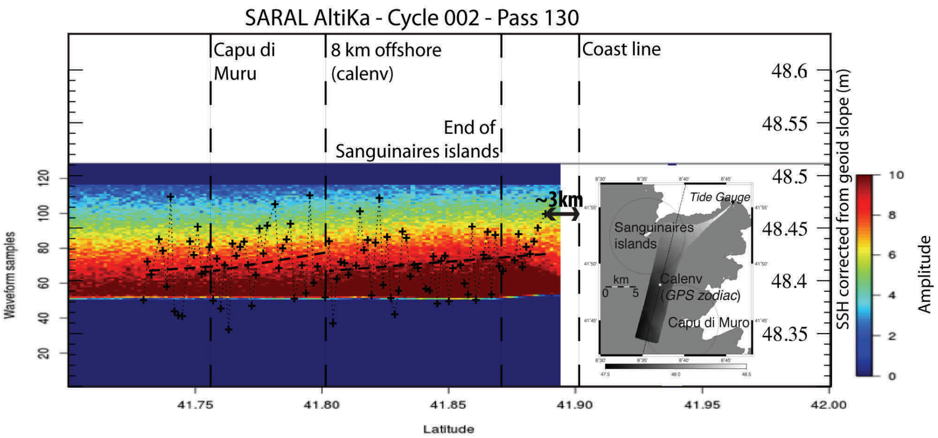


Figure 1: SARAL/AltiKa 40-Hz waveforms for Pass #130 (descending, from coast to sea) on Cycle 002: the waveforms are plotted as latitude (x-axis), gate number (y-axis) and normalized amplitude (color scale). The 40 Hz Sea Surface Heights corrected from geoid slope have been superimposed (crosses). The dashed lines correspond to the linear regressions separated by land location (see small inserted map).

(Credits OCA/Geoazur)

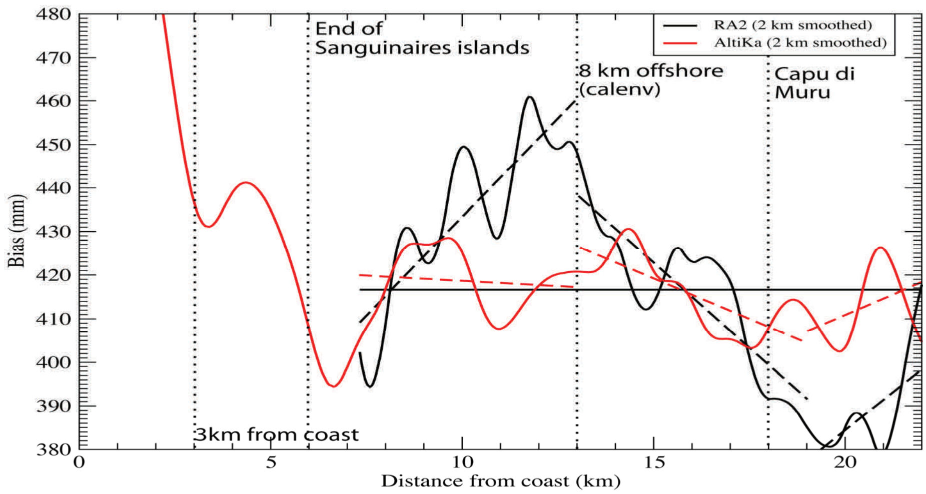


Figure 2: Smoothed high-rate biases in sea-level measurements from tide gauges as a function of distance to the coast for: Envisat in black (Cycles 10 to 93) and SARAL/AltiKa in red (Cycles 1 to 6); a constant has been applied to SARAL/AltiKa bias to be superimposed on Envisat. The dashed lines correspond to linear regressions in the different areas delimited by the vertical dotted lines (see also Figure 1).

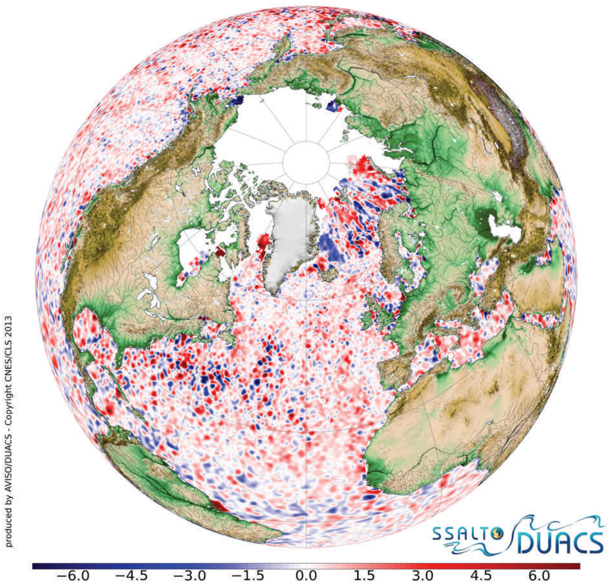
(Credits OCA/Geoazur)

Reference: Bonnefond, P., P. Exertier, O. Laurain, P. Thibaut and F. Mercier, GPS-based sea level measurements to help the characterization of land contamination in coastal areas, Advances in Space Research, Volume 51, Issue 8, Pages 1383-1399, ISSN 0273-1177, 10.1016/j.asr.2012.07.007, 2013.

Ssalto/DUACS: The Jason1 / AltiKa unexpected handover

Prepared by Yannice Faugere, Antoine Delepoulle, Marie-Isabelle Pujol, Frederic Briol — CLS Toulouse, France

SARAL/AltiKa OGDR and IGDR data have been integrated in the CNES-Duacs multimission system on the 1st of July, as soon as they were available, just a few days after Jason-1, the oldest satellite of the altimeter constellation used in Duacs was stopped. Since then, the SARAL/AltiKa , merged with Jason-2 and Cryosat-2 have been used in the system. The Duacs assessment exercise allowed us to confirm the very good performances of SARAL/AltiKa , which allowed us to maintain the products to a rather good quality despite the loss of Jason-1, and even improve them regionally. This improvement is illustrated by Figure 1 were we show that thanks to SARAL/AltiKa , more eddies are retrieved in the area of large oceanic variability and at high latitudes where SARAL/AltiKa data complete interestingly Cryosat coverage. Comparison to other dataset such as ocean color or Sea Surface Temperature (Figure 2) demonstrates that these new structures captured by SARAL/AltiKa are relevant: the mesoscale is better resolved with SARAL/AltiKa (3 satellites) with a better positioning of the eddies. These first results highlight the potential interest of SARAL/AltiKa to even



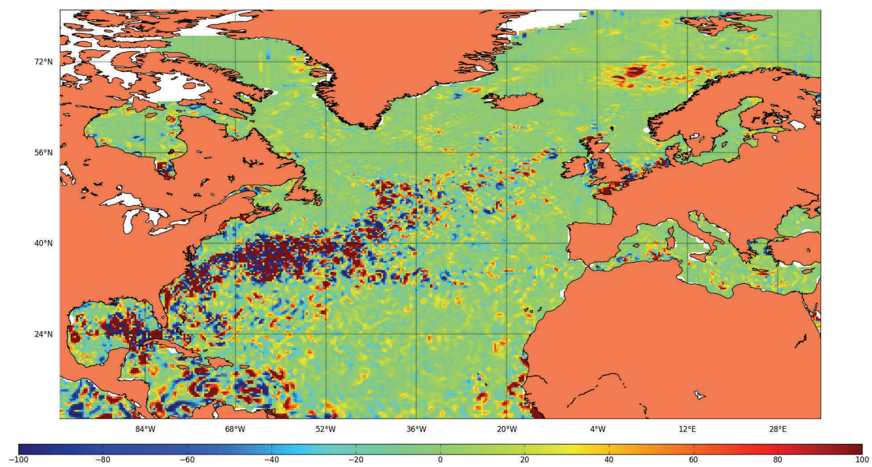


Figure 1: Impact of the use of Altika in DUACS maps. On the right is shown the SLA map difference with/without using Altika on the 6th of June 2013 (unit in cm) before the end of Jason-1. On the bottom is shown the mean Eddy Kinetic Energy difference with/without using AltiKa on the month of July (unit in cm2/s2) where positive values shows the energy re-

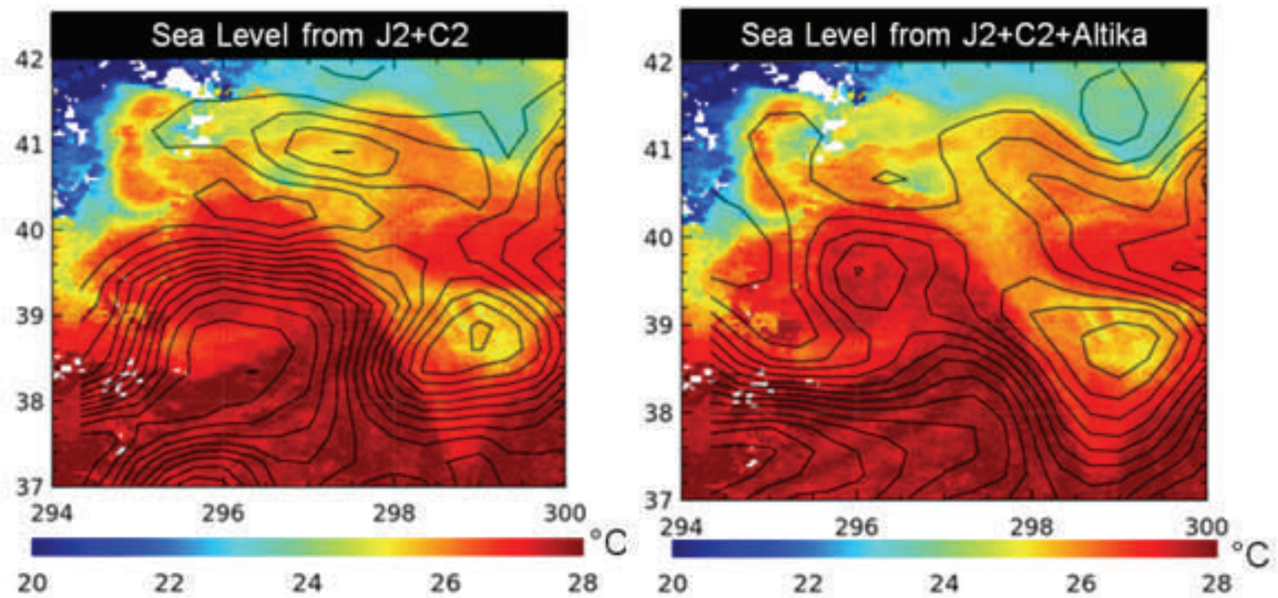


Figure 2: Comparison between DUACS Absolute Dynamic Topography (black lines) to SST(background image) on the Gulf Stream on 26 of July. On the left, Duacs map is computed using Jason-2 and Cryosat-2 data. On the right, Altika data are added in the map computation. (Credits CNES/CLS)

Monitoring the SARAL/AltiKa performance in the Naval Research Laboratory Global Ocean Forecast System

Prepared by James G. Richman and Gregg A. Jacobs — Naval Research Laboratory, Stennis Space Center, USA

Sea Surface Height (SSH) observations from SARAL/AltiKa are assimilated into the global ocean forecast system at Naval Research Laboratory/Naval Oceanographic Office. Prior to assimilation, the SSH data are processed with the software developed at the NRL to monitor altimeter data. Each day, the standard GDR corrections are applied to the near real time altimeter data and a buddy check performed. A once per revolution orbit correction is calculated with an average orbit correction of 4.6 cm for Jason-2 and 6.3 cm for SARAL/AltiKa. The sensor performance is tracked by monitoring the variance of the 20 or 40 hz data each second and computing the crossover differences. SARAL/AltiKa SSH has a slightly lower crossover rms (6.04 cm) compared to Jason-2 (7.06 cm) and lower sensor noise as determined from the 40hz variance (1.03 cm) compared to Jason-2 (1.92 cm). The error characteristics of orbit solution, crossover RMS and flagged data are tracked and available through a web interface .

EM-bias represents a particular challenge for SARAL/AltiKa . Using a wind speed model proposed by Lillibridge, Abdalla and Scharroo, EM-bias is estimated daily. A 30 day moving average of EM-bias is applied to compute the correction for the next day. The corrections for Jason-2 and SARAL/AltiKa are shown in Figure 1. While the SARAL/AltiKa EM-bias is still evolving, the SARAL/AltiKa EM-bias is lower than Jason-2.

The processed data are passed to the global 1/12 degree resolution HYCOM global ocean circulation model developed at NRL. Data assimilation is conducted through a daily cycling 3DVar analysis assimilation scheme. The high quality and short latency of SARAL/AltiKa make the data an important contributor to the forecast system.

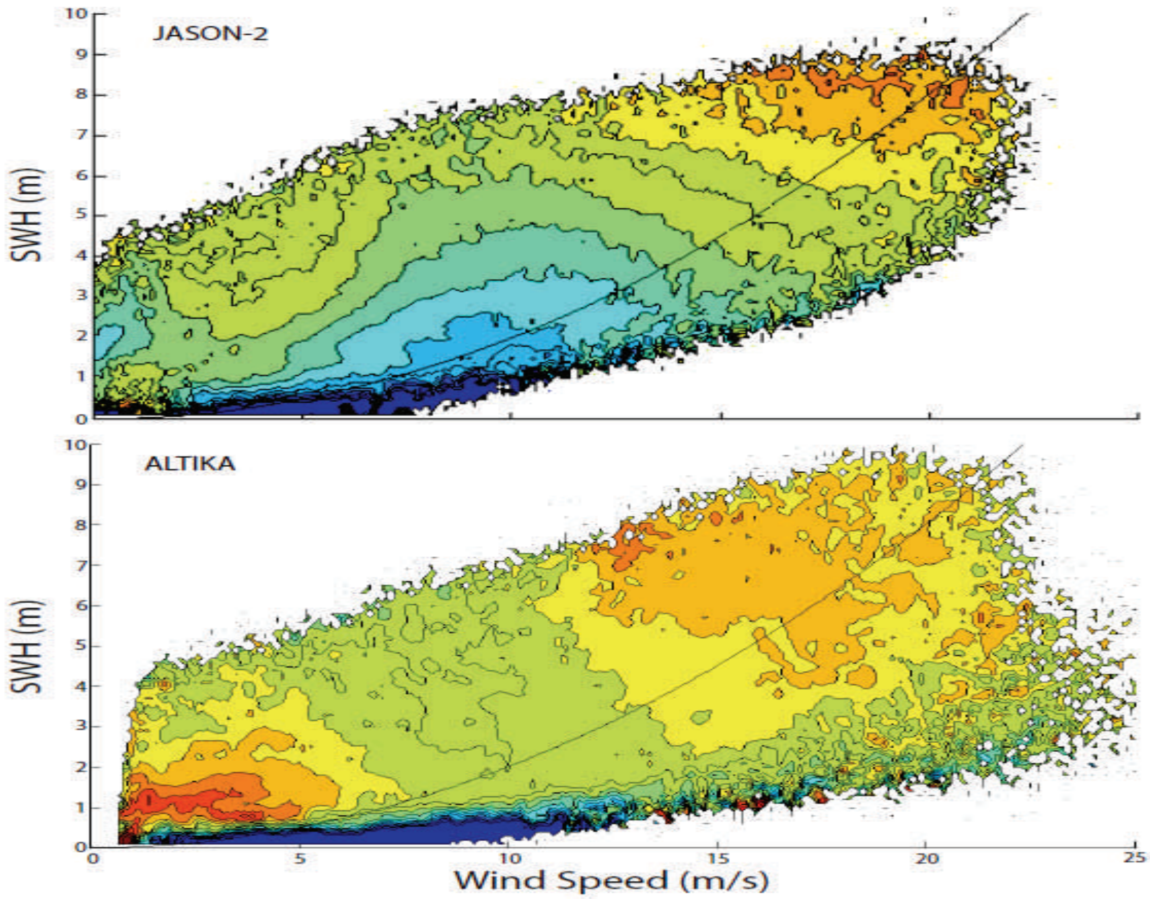


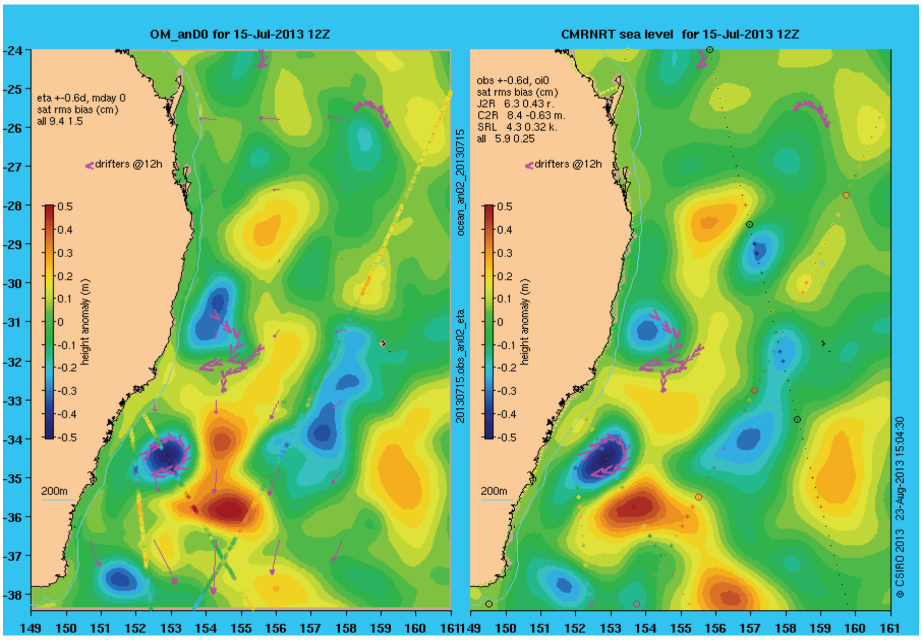
Figure 1: The EM-bias estimated for Jason-2 (upper) and AltiKa (lower) for 10 August, 2013 from the real time monitoring system at NRL. The wind speed is estimated from corrected σ_0 and Ka band version of the Abdalla (2007) provided by Lillibridge, Abdalla and Scharroo. The SARAL/AltiKa EM-bias still needs refinement and more samples, but shows a smaller EM-bias for SARAL/AltiKa than Jason-2. (Credits NRL/US Navy)

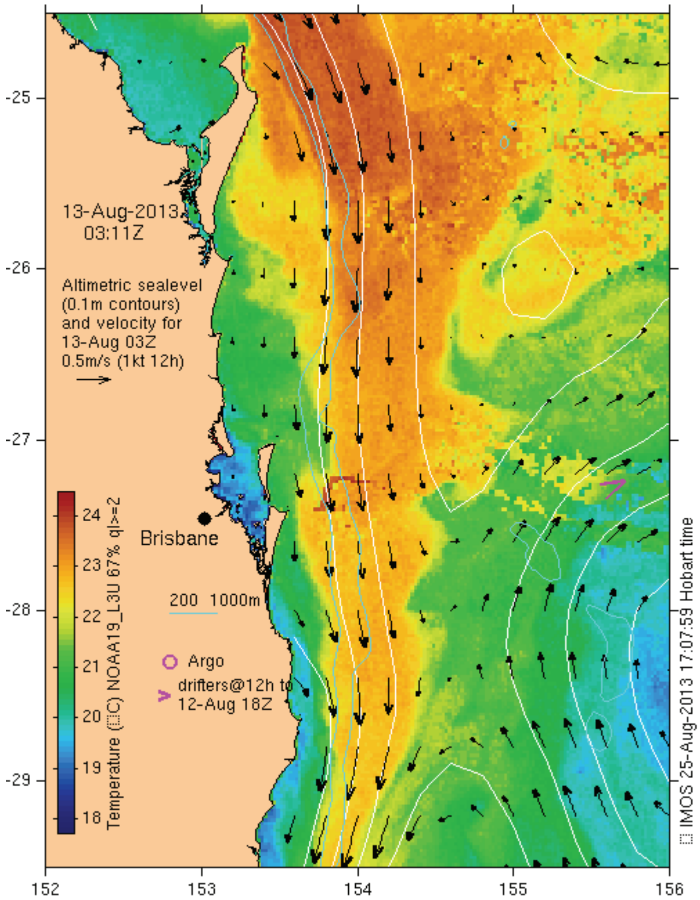
Early use of SARAL/AltiKa in the Australian NRT Sea Level Analysis

Prepared by David Griffin and Madeleine Cahill — CSIRO, Autralia

The Jason-1 mission ended on 21 June 2013, leaving only Jason-2 and Cryosat-2 available for mapping the world's ocean currents. Fortunately, the SARAL project team had just announced a few days earlier that AltiKa data could be used for all purposes. Conscious of the fact that 1) all indications were that the data from AltiKa were of excellent quality, and 2) the reputation of a service can be severely damaged by an outage, no matter what the cause, we did not hesitate to include the data in our real-time sea level mapping systems. For our users, therefore, the (unplanned) 'handover' from Jason-1 to SARAL was essentially seemless, which was an excellent result in the circumstances. We found that our routine data-editing procedures did not need modification, and that rain-induced errors were evidently much rarer than anticipated and look forward to exploring the unique advantages of the AltiKa data, beyond its value as a mere replacement for Jason-1.

To mark the occasion with an anecdote, we have looked through the analyses made at the time of the handover for an illustrative example of the value of the AltiKa data. This was not hard to find.





Figures above show a sea level analysis valid for 15 July 2013, the day that SARAL/AltiKa was the first altimeter to sample a cyclonic eddy off eastern Australia (at 29°S 157°E). Cryosat-2 did not sample it until 30 July, and Jason-2 not until 1 August, at which point the eddy was significantly closer to the outer edge of the East Australian Current (as shown in Figure right), which these eddies are known to disrupt, with much effect on the marine habitat and all stakeholders of the marine environment. (Credits CSIRO)

SARAL/AltiKa capabilities to detect coastal currents in the Western Mediterranean: comparisons with glider data

Prepared by Ananda Pascual[1], Charles Troupin[1], Marc Torner[2], Arancha Lana[1],Guillaume Valladeau[3], M. Isabelle Pujol[3], Yannice Faugère3, Emma Heslop[1], Simón Ruiz[1], Nicolas Picot[4], Joaquín Tintoré[1,2] -
[1]IMEDEA(CSIC-UIB) Esporles, SPAIN - [2]SOCIB Palma, SPAIN, [3]CLS France, [4]CNES France

Recent studies (e.g. Ruiz et al., 2009; Pascual et al., 2010; Bouffard et al., 2012) have shown that underwater gliders constitute an interesting platform for validation and inter-calibration of altimetry data.

In August 2013, a new glider mission (G-AltiKa) was conducted jointly by IMEDEA and SOCIB along a SARAL track. The selected track was located in the Western Mediterranean close to the island of Ibiza, where the SOCIB HF radar facility provided hourly surface current velocities (Figure 1). Surface drifters were also deployed in the studied region. The glider mission (2-5 August 2013) and the passage of the satellite along the selected track were almost simultaneous.

Initial comparisons reveal a reasonable agreement between all platforms (drifter, along-track SARAL/AltiKa and HF radar). The gradient of dynamic height measured by the glider is only in the region of 2-3 cm, but indicates the presence of a coherent meander with maximum associated velocities of about 20 cm/s (Figure 2a). SARAL/AltiKa records (using 40 Hz along-track near real-time data) also capture the meander, with consistent size, amplitude and position compared to glider observations (Figure 2b). Note that SARAL/AltiKa is able to capture the northern edge of the meander, which lies on shallow bathymetry less than 10 km from the coast.

In summary, the preliminary results derived from the G-ALTIKA mission highlight the quality of the SARAL/AltiKa data in the coastal area, even if the associated gradients are weak.

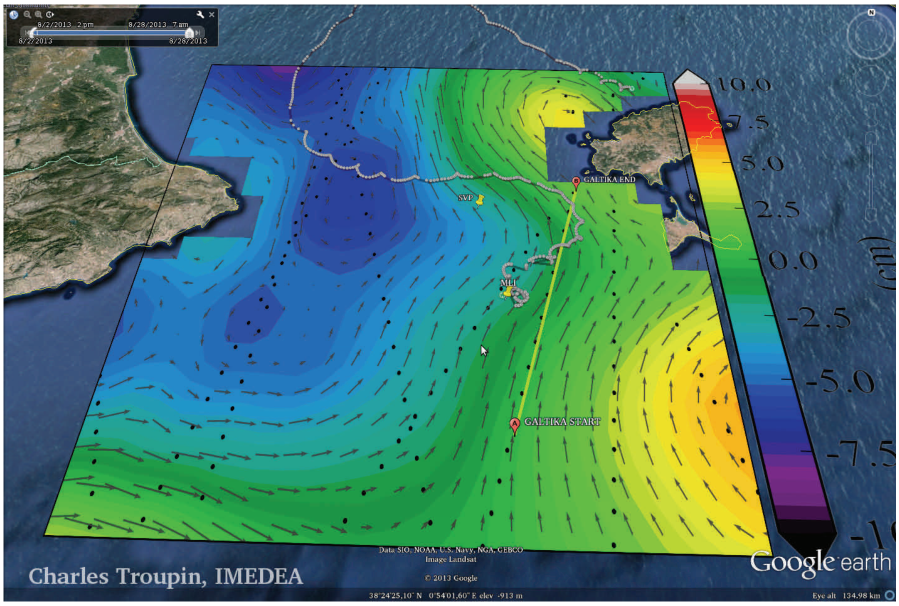


Figure 1: G-AltiKa glider mission definition and drifter deployment location (SVP, MLI). The background color field is ADT obtained from adding gridded NRT SLA (2013/08/01) and the SOCIB-CLS MDT. The vectors correspond to the associated surface geostrophic currents. (Credits IMEDEA)

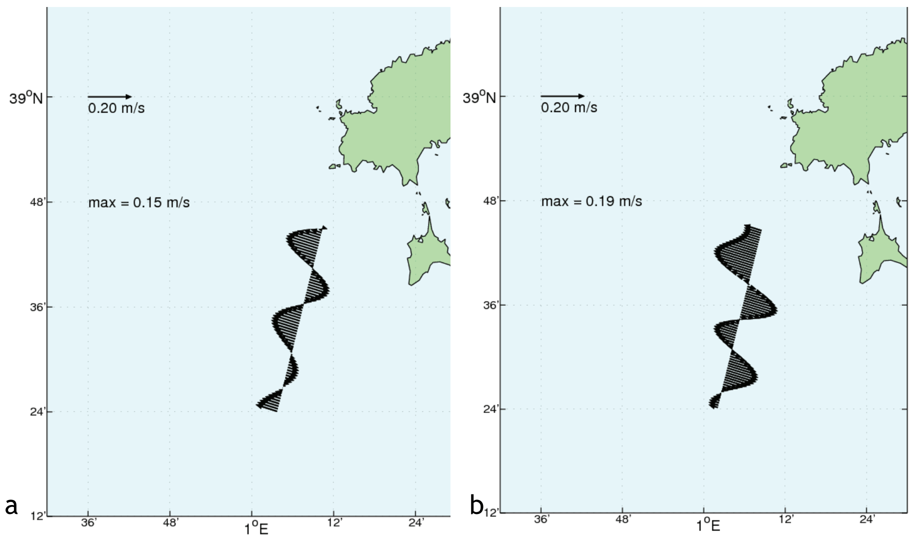


Figure 2: Across track surface geostrophic velocity: (a) SARAL/AltiKa data and (b) glider data. (Credits IMEDEA)

References:

Bouffard, J., Renault, L., Ruiz, S., Pascual, A., Dufau, C., and Tintoré, J.: Sub-surface small-scale eddy dynamics from multi-sensor observations and modeling, Progress in Oceanography, 106, 62-79, 2012.
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Acknowledgements: G-AltiKa experiment was carried out in the frame of MyOcean2 EU FP7 funded project and is a contribution to the SARAL/AltiKa science team. The authors would like to extend special thanks to S. Cusí, C. Castilla. J.-P. Beltrán, K. Sebastián and I. Lizarán for their efficient work during G-AltiKa experiment.

Variability of the Northern Current (NW Mediterranean Sea) observed by along-track altimeter data

Prepared by Florence Birol, Fernando Niño, Sara Fleury, Denis Blumstein and Rosemary Morrow — CTOH/LEGOS, Toulouse France

In the Northwestern Mediterranean Sea (Figure 1), the main feature of the ocean circulation is the Liguro-Provençal-Catalan Current (LPC). This surface boundary current flows cyclonically along the coasts of Italy, France and Spain and is highly variable (in both time and space).

Satellite altimetry is widely used for observing the sea surface currents but near the coasts, its performance differs significantly from that over the open ocean, leading to a strong increase in measurement errors. The length scales of coastal dynamical processes are also small (0-50 km) in comparison to the spatial sampling provided by standard altimeter products.

Despite its narrow width (~20-50 km), the LPC can be detected by altimetry. The new SARAL/AltiKa altimeter instrument, expected to provide a higher spatial resolution, should allow a better observation of this boundary current than conventional Ku band altimeters.

Here, assuming geostrophic balance, the cross-track surface geostrophic velocities are calculated from both Jason-2 and AltiKa sea level gradients (Figure 2; a time window of 10 days has been chosen to compute each individual frame of the movie). The boundary circulation that emerges from the observations provided by both altimeters appears spatially coherent. Despite of its 35-day repeat orbit, SARAL/AltiKa really improves the observation of the LPC coastal current along its path. The performance of SARAL/AltiKa appears also very good near the coast.

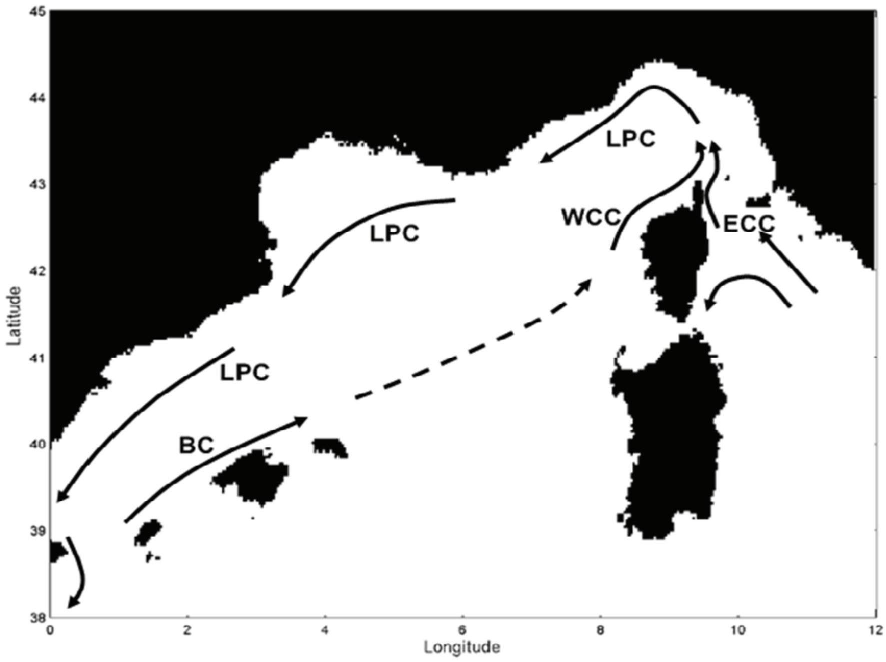


Figure 1: Schematic view of the major ocean circulation features in the Northwester Mediterranean Sea. (Credits LEGOS)

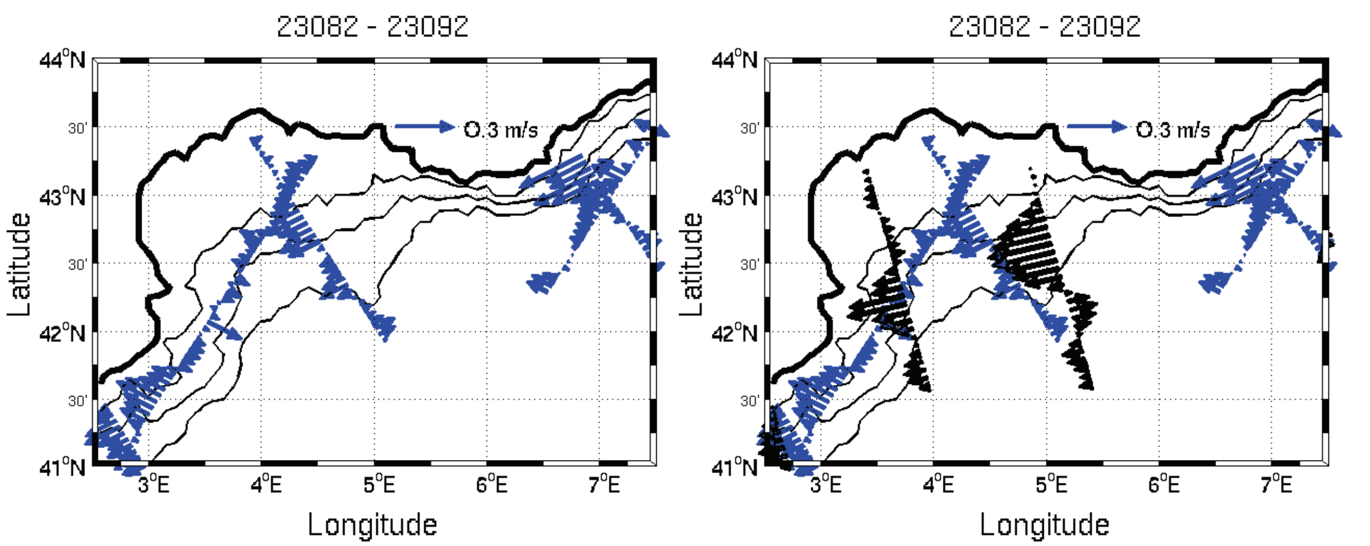


Figure 2: Cross-track geostrophic currents derived from Jason-2 (blue arrows) data only (left) and from both Jason-2 (blue arrows) and AltiKa (black arrows) data between 12 and 22 April 2013. Click on the image to visualize the animation. (Credits LEGOS)

Assimilation of SARAL/AltiKa Significant Wave Height (SWH) into a Numerical Operational Prediction (NWP) system

Prepared by L. Aouf and J.M. Lefèvre — Météo France Toulouse, France

The assimilation of altimeter wave data is an important component of the operational wave forecasting system used by Météo-France. Since the launch of the SARAL satellite, impact studies have been developed to evaluate the use of AltiKa wave data in the corresponding assimilation system of Météo-France. During CAL/VAL activities, a robust quality control procedure is implemented to eliminate any corrupted data in the wave forecasting system. Assimilation runs have been performed for more than 5 months of data. Preliminary results have shown that the assimilation of SARAL/AltiKa wave data in the MFWAM wave model improves by roughly 20% the estimate of significant wave height in the period of analysis (see Figure 1 below). Also, the peak period of the wave spectrum is considerably improved in comparison with the data from buoys. The assimilation conjointly of SARAL/AltiKa and Jason-2 increases the impact and induces for example a normalized root mean square (NRMS) error of significant wave height of less than 9% in the tropics. In the period of forecast, the impact of using SARAL/AltiKa remains effective for 3 days after stopping the assimilation, as illustrated in Figure 1 (variation of the normalized scatter index of significant wave height in the forecast period).

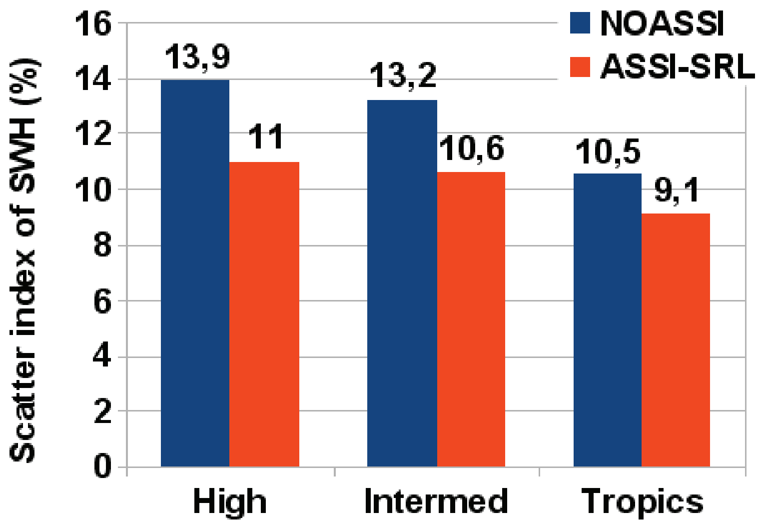


Figure 1: Normalized scatter index of significant wave heights for different ocean basins. The blue and red represent the run without assimilation and the run with assimilation of SARAL, respectively. (Credits Météo-France)

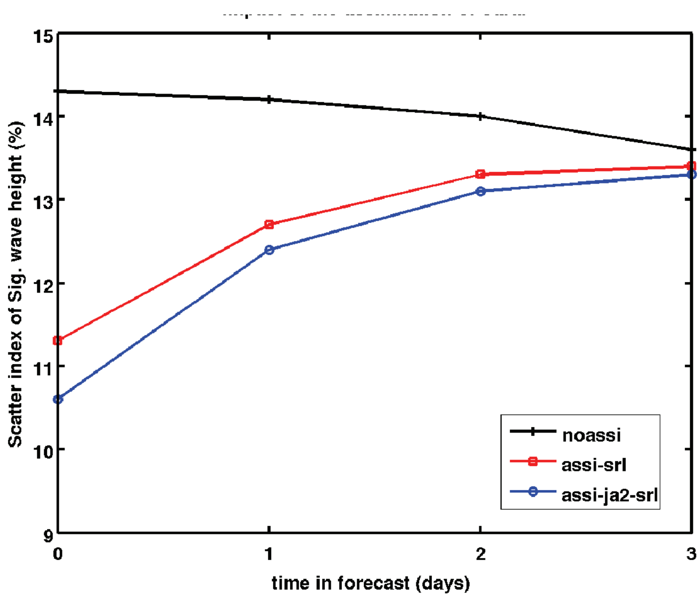


Figure 2: Variation of the normalized scatter index of significant wave height in the period of forecast. Black plus curve stands for the run without assimilation. Red and blue stand respectively for the run of the assimilation of Saral only, and the run of the assimilation conjointly of Jason-2 and Saral. (Credits Météo-France)

SARAL/AltiKa: Altimetry over rivers

Prepared by Stéphane Calmant — LEGOS Toulouse, France, Joécila Santos da Silva — Univ. Esta. Amazonas, Manaus, Brazil, Daniel Medeiros Moreira — CPRM, Rio de Janeiro, Brazil, Frédérique Seyler — Espace, Cayenne, French Guyana.

From 2002 to 2010, thousands of time series of water level measurements over land masses were collected by Envisat, ESA's satellite which flew on the same orbit as SARAL, ~1000 of which were for the Amazon basin alone. Owing to the performance of SARAL/AltiKa over these water bodies, which exceed that achieved by Envisat, SARAL/AltiKa will permit the continuation of these Envisat time series. These performances are illustrated in Figure 1, where we compare SARAL/AltiKa water levels over a very narrow channel of the Pardo River, in the Amazon basin. There, SARAL/AltiKa passes at a crossover twice in 1.5 days. Assuming that the difference in elevation between the pairs of passes at each cycle is only due to measurement error, a conservative hypothesis since it neglects the variability of the water level, we obtain a rms difference of 17 cm for the first 6 cycles, largely below the one obtained with Envisat (24 cms).

A major application of altimetry for rivers is the conversion into discharge estimates. Prior to the launch, we had computed Stage-Discharge relationships based on the Envisat data throughout the Amazon basin, including in the Andean piedmont where hydrological information is scarce and late. With SARAL/AltiKa, we can predict the discharge at each of these places with very little delay; owing to the very fast delivery of the I-GDR data.

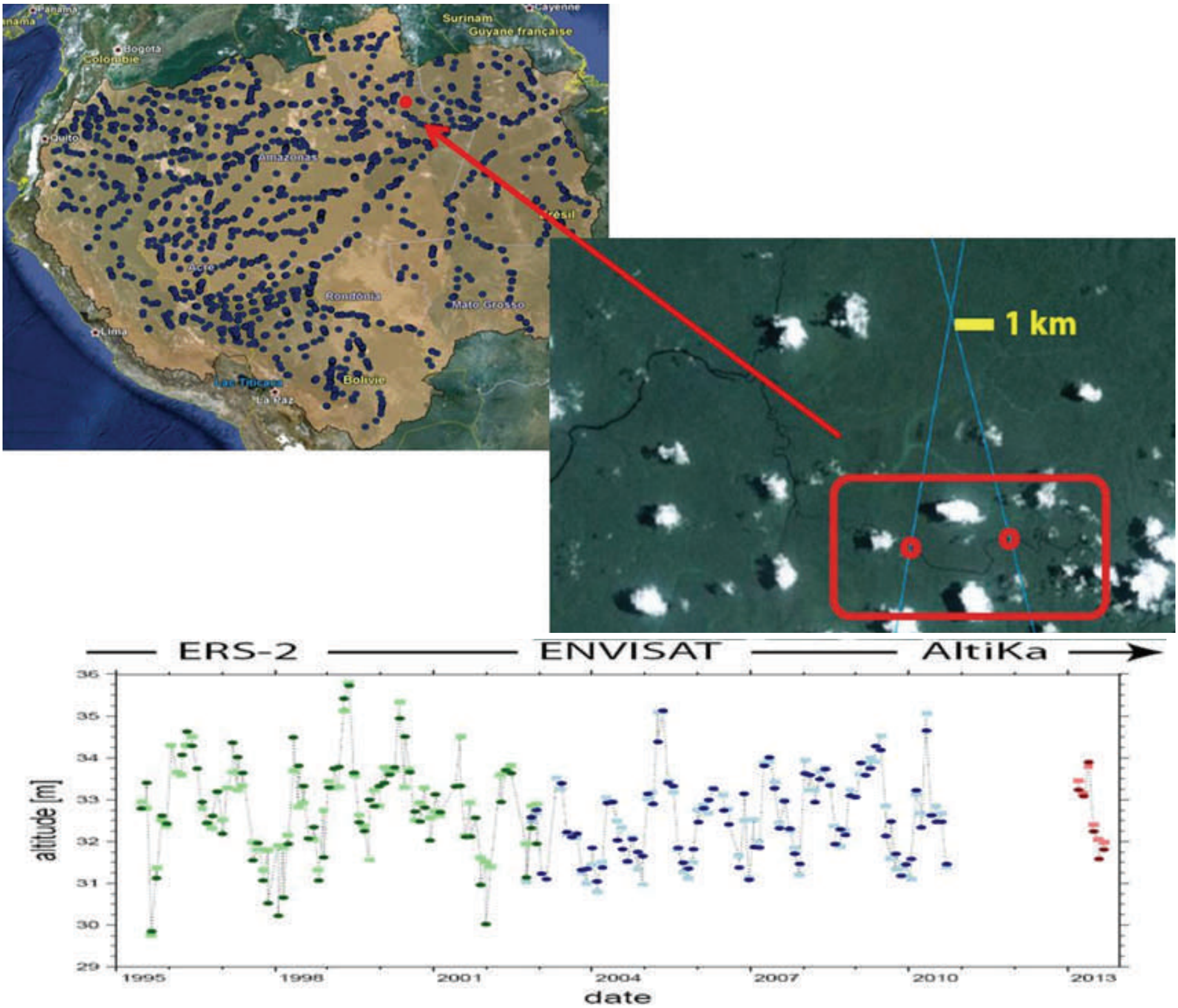


Figure 1: Upper left: localization of the ~1000 SARAL sites in the Amazon basin
Center: Zoom on the Pardo river.
Lower panel: elevation series for ERS-2 (green dots, Envisat (blue dots, and SARAL (red dots). The rms between the pairs of measurements (light and dark tone) is 40 cm for ERS2, 25 cm for Envisat and 17 cm only for AltiKa. (Credits IRD/LEGOS)

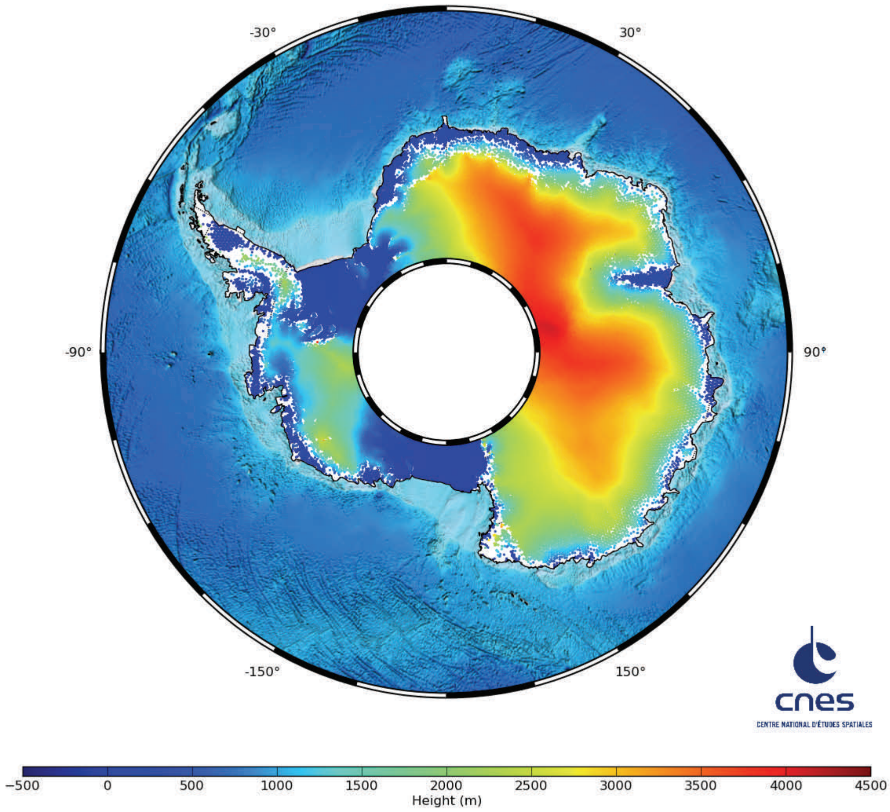
SARAL/AltiKa: promising observations for ice sheet studies

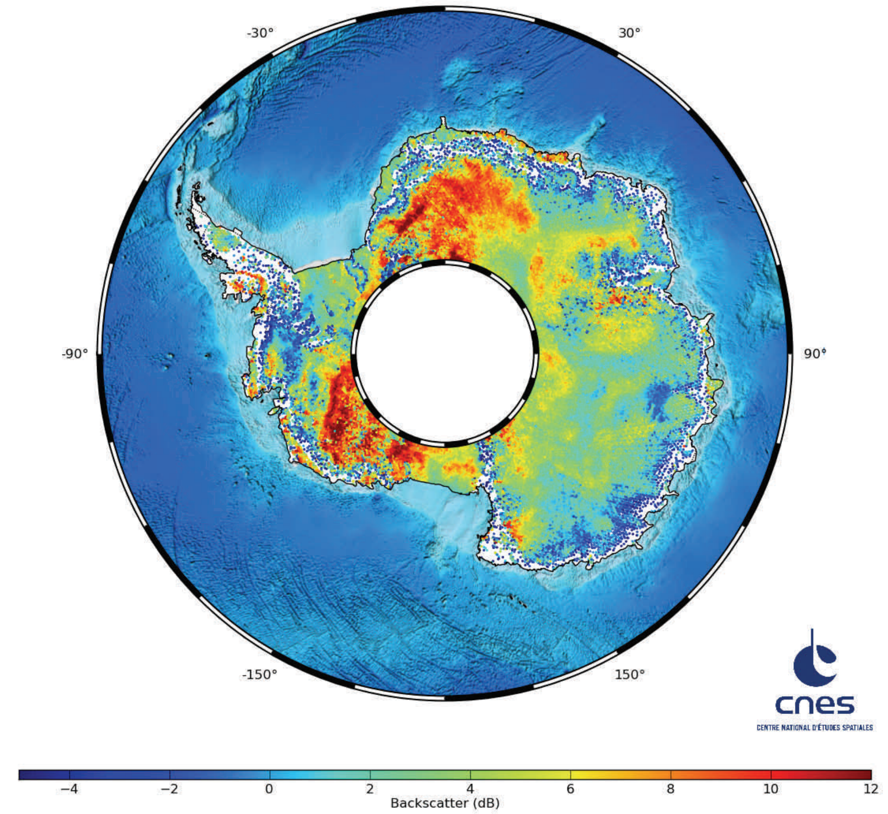
Prepared by Aurélie Michel — CLS/CNES/LEGOS, Toulouse France)

From 1991 to 2012, ERS1, ERS2 and Envisat surveyed ice sheets like those of Greenland and Antarctica and provided us with precious information regarding the surface properties, the contribution of ice sheets to sea-level rise or the volume mass balance.

After the Ku-band era (13.6 Ghz), here comes SARAL with the Ka-band (35.75 Ghz). Less than one year after its successful launch, we have acquired many observations over land ice. The waveform parameters such as the leading edge width or the backscatter (plotted here for the 2nd SARAL cycle for the Antarctic ice sheet) are lower in the Ka-band than the Ku-band. More hindsight is needed to confirm our results but it seems that the penetration depth is smaller. Large temporal fluctuations between cycles for the backscatter are observed whereas they are rather small for the surface height.

We even observe the same geographical patterns but not at the same frequency. All of this suggests that the radar echo comes from the upper layer of the subsurface. By comparing with former missions and continuing our monitoring, we will be able to enhance our understanding of the Ka-band, the Ku-band and the dynamics of the ice sheets and eventually to better estimate the temporal variations in topography (as plotted by SARAL).





Figures: Maps of backscatter coefficient (in dB, bottom) and toppography (in m, up) over the Antarctica ice sheet. The measurements are provided by the AltiKa altimeter on the *Saral* satellite for its second cycle (cycle_002: 2013/04/18 - 2013/05/23).

Credits CNES/CLS 2013

Detection of Ships and Icebergs using AltiKa high rate waveforms

Prepared by Jean Tournadre and Michaël Accensi — Laboratoire d'Océanographie Spatiale, Ifremer, France

Any target emerging from the sea, such as iceberg or ships, small icebergs, can produce a detectable echo before the sea surface, i.e., in the noise part of the altimeter waveforms [Tournadre, 2007]. This signature is detectable, if the backscattered power is high enough to come out of the thermal noise of the sensor and if the time of the echo is within the measurement window of the system. This method have been successfully used to estimate the distribution of iceberg in the Southern ocean using Jason-1 20 Hz waveform data.

The better resolution and lower noise of the Altika altimeter allows a better detection of both ships and icebergs.

As illustrated in Figure 2 with 4 months of SARAL/AltiKa data, the major ships lines can already be clearly seen as well as the main regions of icebergs concentration showing the quality of the altimeter.

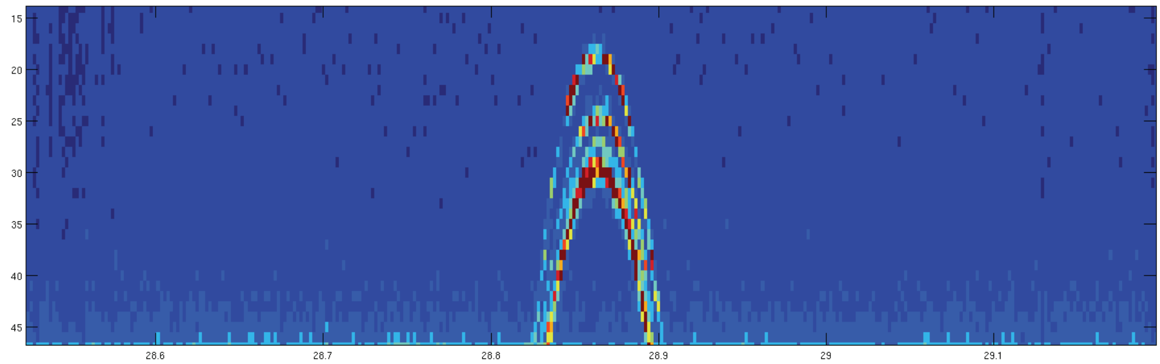


Figure 1: Example of a ship signature in the noise part of the waveform where three parabolas corresponding to the different ships deck are visible. (Credits Ifremer)

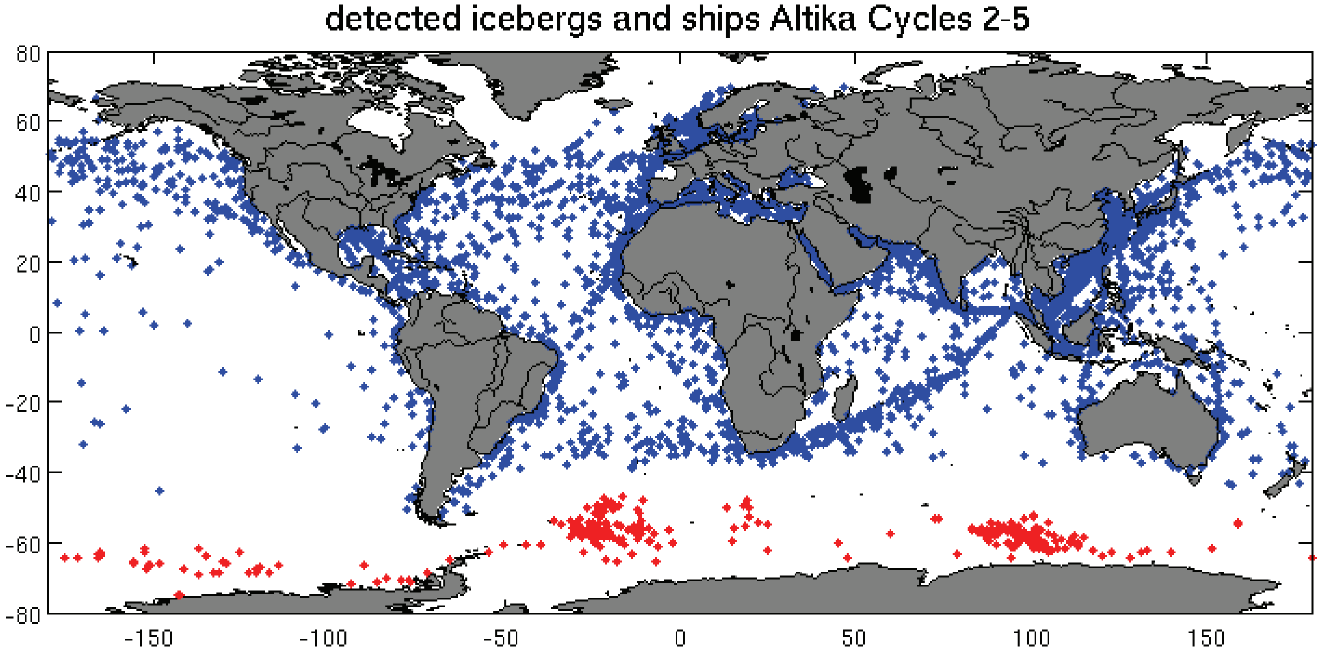


Figure 2: Ships (blue dots) and icebergs (red dots) detected during cycles 2 to 5. In only 4 months, the major ships lines can already be clearly seen as well as the main regions of icebergs concentration showing the quality of the altimeter. (Credits

Reference: Tournadre, 2007: Signature of lighthouses, ships, and small islands in altimeter waveforms. *Journal of Atmospheric and Oceanic Technology*, 24(6), 1143-1149. http://dx.doi.org/10.1175/JTECH2030.1 ■