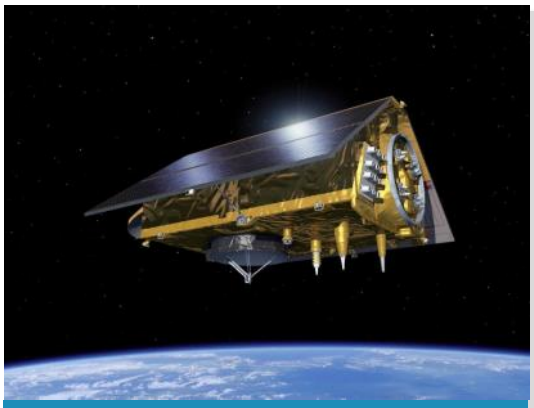
AVISO+ Satellite Altimetry Data

Users Newsletter

#17

October 2020



SUMMARY

Project news

CNES project managers

The virtual altimeter constellation still includes six operating satellites. Since the last AVISO+ newsletter, China's HY-2A satellite has stopped taking measurements, its brother HY-2C has been launched and should be fully operational within a few weeks. This constellation in orbit will enable dedicated analyses with a better calibration at crossovers points, a finer scale mapping for mesoscale circulation and regional products, and a limited impact on operational products when an anomaly occurs.

Current Missions

Sentinel-3 is a mission set up by the European Commission to measure sea surface topography, sea- and land-surface temperature, and ocean- and land-surface colour. Sentinel-3 is one of a series of missions, each covering a different aspect of Earth Observation and monitoring. Sentinel-1 is an SAR-dedicated satellite while Sentinel-2 is carrying an optical payload. Sentinel-3A was launched on 27 February 2016 and is currently in nominal operation, handled by ESA and EUMETSAT. Sentinel-3B was hoisted into space in April 2018 by rocket launcher and successfully completed its commissioning phase at the end of 2018. Following a tandem phase with its twin Sentinel-3A (flying 30 seconds ahead, corresponding to ~223 km), which provided the key data set required to ensure homogeneity between both missions and a second data set for supporting specific studies, Sentinel-3B was placed in operational orbit in November 2018. The altimeter was also uploaded with new Open-Loop Tracking Command (OLTC) tables, used to control the return echo acquisition phase of the altimeter by setting its reception

window. Available on both satellites, these tables provide unique coverage of inland water bodies with over 65,000 inland water targets. Sentinel-3A and 3B satellites are working well and ESA is continuing to work on the development of Sentinel-3C and 3D.

Jason-3, which is still a reference altimetric mission, with excellent product quality and a very high availability rate, is preparing to receive Sentinel-6 (Jason-CS) on the reference altimetry orbit, for a one-year period of tandem flight and inter-calibration. This will then allow Jason-CS to resume recording continuous sea-level measurements, a mission that has been ongoing for more than 30 years. In view of the good technical condition of the satellite and its instruments, the programme's partners (CNES, EUMETSAT, NASA, JPL and NOAA) have decided to continue the mission until 2025.

On 3 September 2020, Jason-3 was equipped with a new Digital Elevation Model, which now allows it to perform measurements over land for seven times more hydrological targets than with the previous version (i.e. about 31,500 targets). Show about the "**New upgrades to OLTC tables** » page 13.

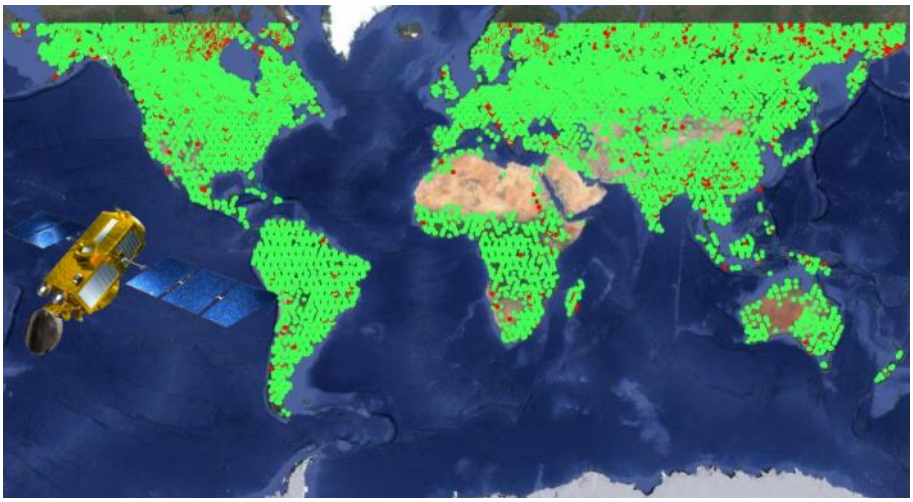
SARAL, a French-Indian mission run by CNES and ISRO (Indian Space Research Organization) with the participation of EUMETSAT, was launched on 25 February 2013. In early 2019, SARAL encountered a number of issues affecting the nadir pointing accuracy. The ISRO team was able to improve the situation by mid-April 2019 using new operational procedures. However, the availability and quality of data measurements may be degraded from time to time and users should remove any ocean data with "off_nadir_angle_wf" over 0.09 deg². The SARAL mission is officially scheduled to continue until the end of 2021.

HY-2A and **HY-2B**, launched in August 2011 and October 2018 respectively, are Chinese missions with French/Chinese collaboration between CNES and CNSA / NSOAS for altimetry (DUACS) and orbitography products (IDS). On 23 March 2016, the HY-2A satellite was moved from its nominal orbit to an orbit 2 km higher. The new orbit has a 168-day cycle with 2,315 orbits in the full cycle. In June 2020, HY-2A entered a new phase referred to by our Chinese colleagues as "orbit maintenance state". All onboard payloads excluding DORIS were switched off and all operations suspended. HY-2A is now no longer considered as operational. As reported in AVISO+ newletter#16, data from HY-2B are now contributing to DUACS/ CMEMS. On 7 July 2020, the DUACS Near-Real Time system started using HY-2B altimeter measurements, bringing to six the number of altimeter missions processed (further information on this in AVISO+ news). During the summer, HY-2B played a significant role in limiting the impact of the loss of CryoSat-2 data, which was temporarily deactivated in the system (see below).

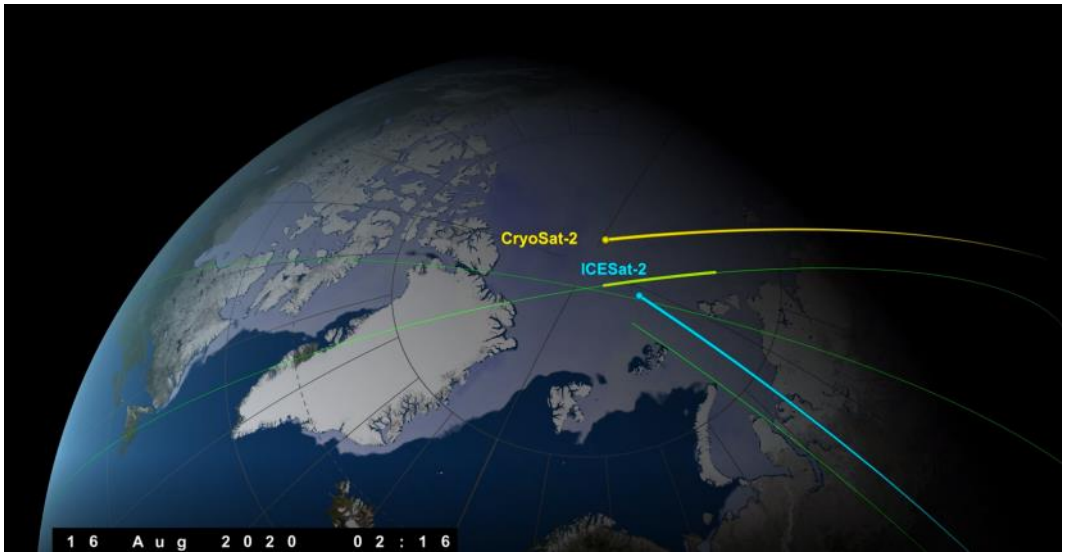
HY-2C, the third satellite in the Hai-Yang 2 series, was recently launched on 21 September 2020 from the Chinese launch base of Taiyuan. The outset of the mission is operating at nominal levels, and the flows of DORIS orbit-related data are beginning to circulate.

ESA's **CryoSat-2** ice mission, celebrated its tenth anniversary in orbit on April 8, 2020! "Still cool at 10!" as reported by ESA, it continues to play a complementary role in the multi-mission SSALTO/DUACS system providing value-added products (levels 3 & 4). The CryoSat-2 mission is expected to continue at least until the end of 2022, given that there is no sign of degradation on the platform or radar altimeter for the moment. In summer 2020, several orbital manoeuvres were performed in order to increase the altitude of the satellite by about 900m. The purpose was to increase the overlap with the US ICESat-2 satellite. Given their different orbit altitudes, the result is a roughly 3,000 km stretch of sea ice that is measured by both ICESat-2 and CryoSat-2. By combining data from these two sensors, scientists will be able to measure the thickness of the snow layer and produce substantially improved estimates of sea ice thickness. An animation is available here (see capture page 3).

Two satellites (**SARAL** & **CryoSat-2**) are in a geodetic and/or LRO orbit, thus providing dense coverage of the ocean surface.



*Acquisition score of the hydrological targets defined in the new **Jason-3** onboard DEM, here for cycle 169. In green, score OK (success). In red, NOK score (failure). This score is based on the analysis of the waveforms measured by Jason-3 to ensure that the altimeter records a signal coming from the hydrological surface. Credits NOVELTIS/CNES.*



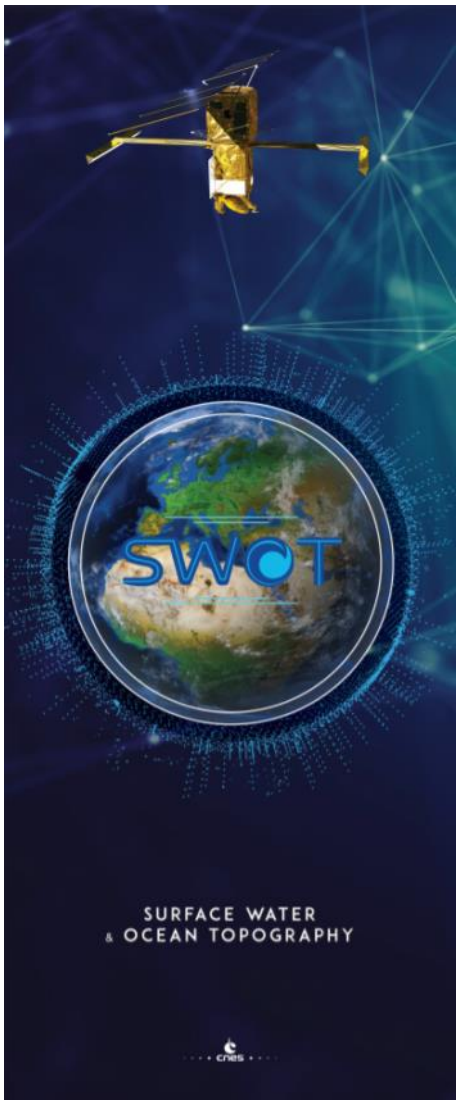
Capture from the animation showing the coincident measurements between ICESat-2 and CryoSat -2 over the Arctic area. Credits Nasa Scientific Visualization Studio.

The French-Chinese satellite **CFOSAT** was launched on 28 October 2018 while the French wave radar, **SWIM**, was activated on 1 November. After a one-year period of data qualification by expert groups and members of the CFOSAT international science team, CFOSAT SWIM data were delivered to all users on 19 February 2020. Data processed from the nadir beam signal, i.e. significant wave height and wind speed, were used for operational and scientific applications. Data processed from off-nadir beams, i.e. wave spectra and parameters, were limited to scientific applications, owing to a number of limitations identified in the 2019 SWIM Calval Report. Teams from CNES, Latmos, IFREMER, LOPS, CLS and Météo-France worked on improvements in processing. As a result of their work, a new issue of the product became available on 25 June 2020 for operational and scientific applications involving all data. Page 6 includes a description of the two main upgrades.

Ongoing developments

Sentinel-6A/Jason-CS-AMichael Freilich, the first of a two-satellite Sentinel-6 series, is scheduled to be launched by a Falcon-9 rocket from Vandenberg Air Force Base, California, on 10 November 2020. Also known as Jason Continuity of Service (Jason-CS), the Sentinel-6 satellites will replace the Jason-3 satellite, thus ensuring the continuity of operational oceanographic services on the reference orbit beyond 2030. The development of this new generation of Jason satellites is making progress according to plan. Sentinel -6A/Jason-CS-AMichael Freilich was stored in IABG Ottobrun (Germany) and shipped to Vandenberg (California – USA) in an Antonov cargo plane on 23 September after receiving the greenlight from the JSG meeting on 17 September.

SWOT (Surface Water and Ocean Topography) is a French-American mission run jointly by CNES and NASA, with the participation of UKSA and CSA, to study oceanic and inland water surfaces. Development of the flight system is well advanced, the assembled platform has been stored on the premises of THALES, and payload integration and tests are progressing but have been slowed down by the pandemic. The final integration and testing of the satellite are scheduled to start in 2021 with a current launch date for early 2022, to be reassessed in the light of the impact of the pandemic. Ground system tests are ongoing, the satellite Control Centre has been already delivered and the mission centre is currently beginning the AI&T phase.



New version of the El Niño Southern Oscillation index

AVISO+ Team

Based on altimeter sea level measurements, the ENSO index provides an estimate of the variations and intensity of El Niño, a large-scale phenomenon closely linked to ocean circulation and climate variations. In January 2020, processing of the ENSO index was updated to correct the altimeter sea level maps for each grid point trend.

The ENSO index is computed using pre-processed altimeter sea level maps, corrected for annual, seasonal and 60-day signals. However, the maps are not corrected for the long-term trends that directly impact the final indicator.

In January 2020, processing of the ENSO index was updated to correct the altimeter sea level maps for each grid point trend. In addition, the reference period applied to estimate periodic signals was changed from 1993-2013 to 1993-2016. Further information on these changes can be found on the AVISO+ website.

Impact on the maps

Figure 1 below illustrates the impact of these changes on the monthly map of sea level anomalies (November 2018) used as input for computing the ENSO index. In the 2020 version (bottom), sea level anomalies remain centered whereas in the previous version (top), prior to removal of the trend, the map is saturated with red positive values.

Impact on the time series

The impact of the upgrades on the ENSO index time series can be seen in figure 2 below, which shows two curves corresponding to the previous (yellow) and 2020 (green) versions. The removal of the sea level trend directly affects the determination of periods relating to El Niño (positive) or La Niña (negative) events.

Links to download

All the monthly mean sea level anomaly maps for the [1993-2020] period were computed with these changes, and can be visualised in the interactive ENSO bulletin. The time series can be downloaded from the FTP.

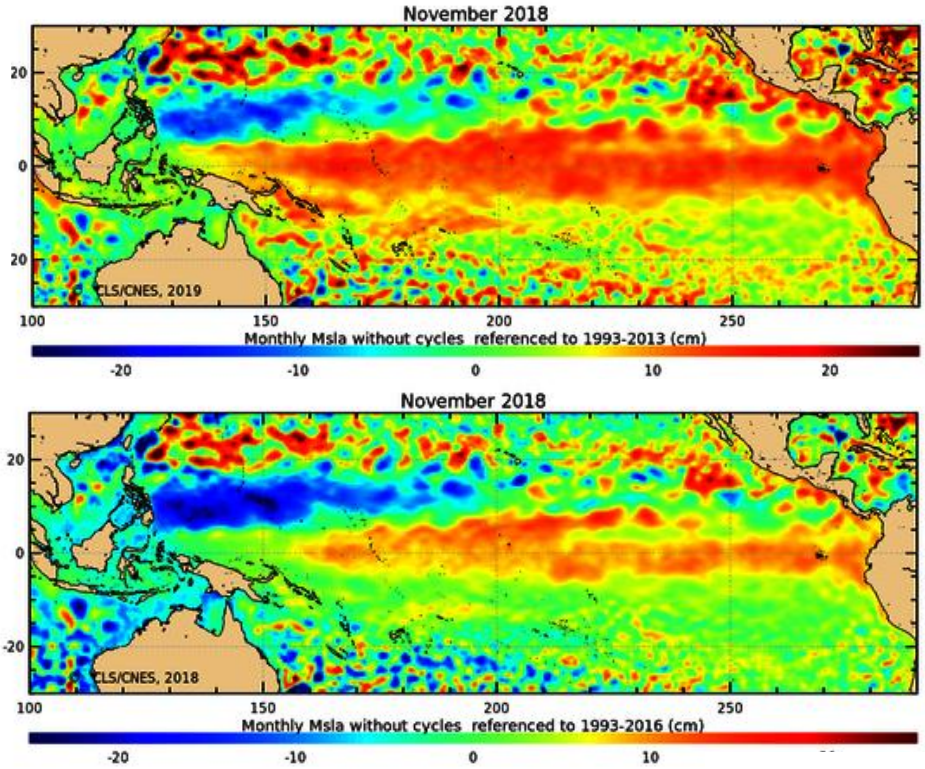


Figure 1 : Monthly mean of Sea Level Anomalies over the Tropical Pacific for the previous version (top) and with the changes implemented in 2020 (bottom). Credits CLS/CNES.

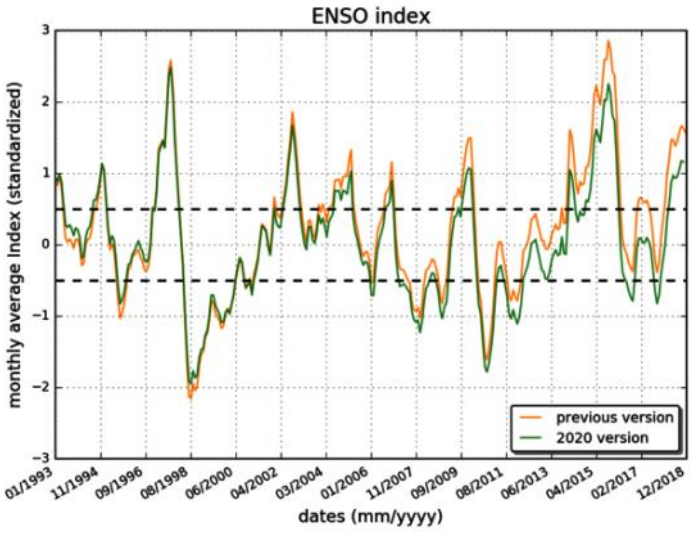


Figure2 : Standardized Sea Level Anomalies over the Nino3.4 region with previous and 2020 versions. Credits CLS/CNES.

AVISO+ : a wide range of altimetry products

AVISO+ Team

Sea surface height and derived products

- Monomission Corrected Sea Level Anomalies (L2P)
- Ssalto/Duacs experimental along-track and gridded Sea Level Heights and velocities,
  New gridded **multimission** SLA dedicated to Arctic,
  New version of **along-track** SLA 5 Hz
- Ssalto/Duacs Climatology Maps of Sea Level Anomalies
- Ssalto/Duacs along-track and Maps of Sea Level Anomalies heights and velocities (Mozambique)
- Geophysical Data Records
  New Saral/AltiKa reprocessing
  Soon T/P reprocessing

Ocean indicators

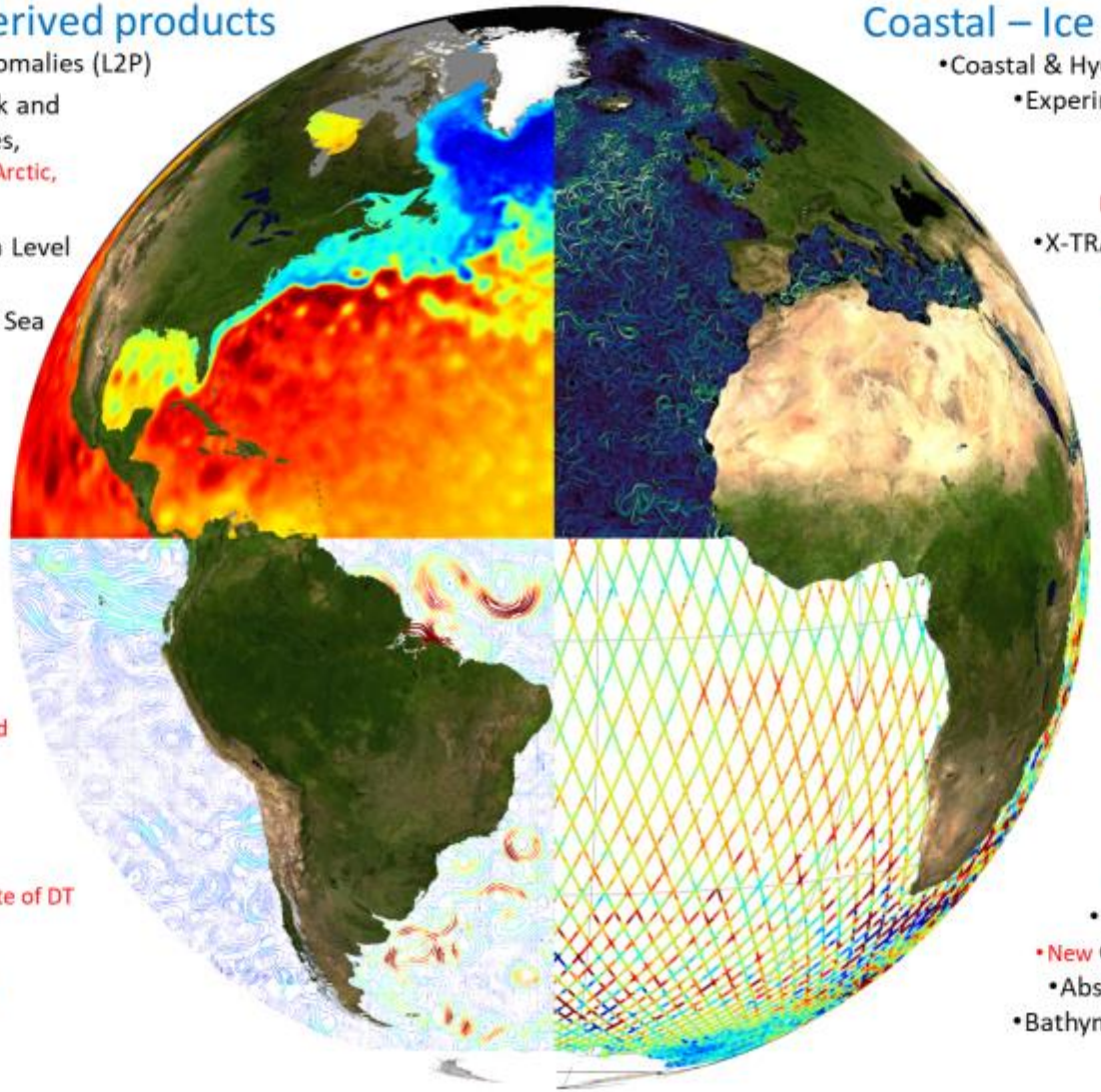
- Mean Sea Level
- Kuroshio index
- Ionian Sea index
- ENSO index & maps new without SL trend

Value-added products

- Lyapunov exponents or Filaments
- Mesoscale eddy trajectory atlas: Update of DT

Data Challenge products

- Soon SWOT Data Challenge NATL60



Coastal – Ice – Hydrology products

- Coastal & Hydrology Geophysical Data Records
- Experimental Geophysical Data Records:
  New Sentinel-3A products
- Sea ice product:
  New Alti Snow Depth + Soon Antarctica
- X-TRACK Coastal Sea Level Anomalies:
  new reprocessing
- New SGDR+ Ice Sheet SARAL products

Wave heights and wind speed

- Maps of SWH, new reprocessed
- Maps of Wind speed, new reprocessed
- Along-track L2P Wave NRT for Sentinel-3A, Sentinel-3B and CFOSAT,
- New CFOSAT SWIM wave and SCAT wind products

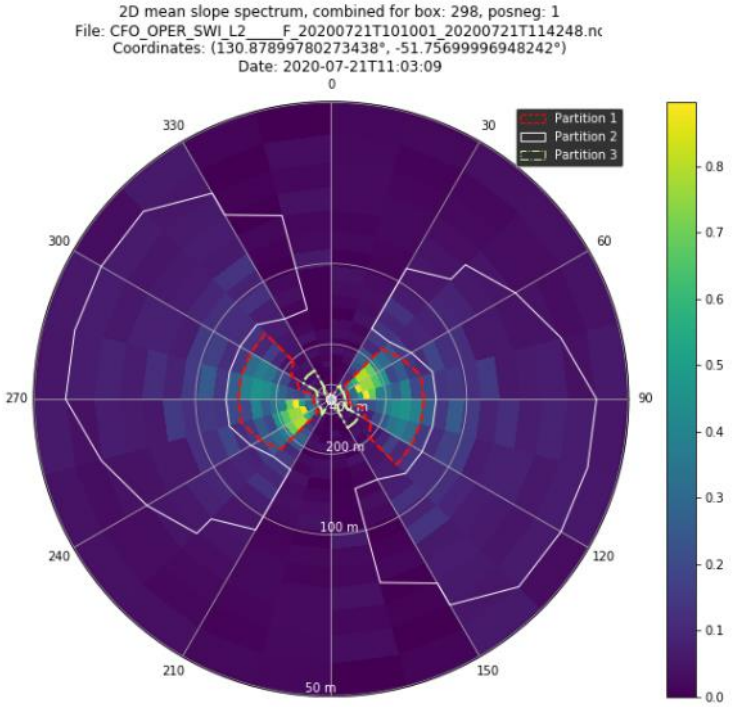
Auxiliary products

- Tidal model
- Mean Sea Surface Soon
- Mean Dynamic Topography
- New X-TRACK coastal tidal constants
- Dynamic Atmospheric Corrections
- New GDP+ wet tropospheric correction
- Absolute calibration tide gauge series
- Bathymetry from FES14 tidal model Soon

CFOSAT SWIM processing evolution

CNES, Cédric Tourain

The French-Chinese satellite CFOSAT was launched on 28 October 2018. As a result of the work from CNES, Latmos, IFREMER, LOPS, CLS and Météo-France, a new issue of the product became available on 25 June 2020 for operational and scientific applications involving all data. A description of the two main upgrades is provided hereafter.



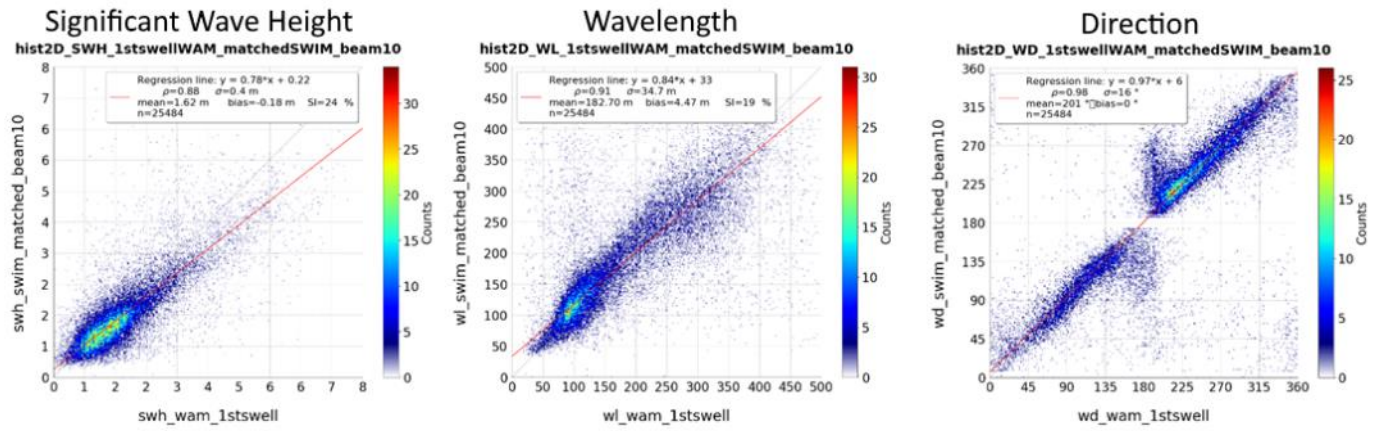
2D mean wave slope spectrum for one CFOSAT/SWIM box (90km x 70km) on 2020/07/21. Associated wave parameters (height, direction, wavelength) given in the table. Credits CNES/CLS.

SWIM v5.0.1 improvements

The new issue of the product, mitigates an onboard anomaly impacting the power of some measurements (around 7% in average over the mission lifetime). The impacted measurements are identified, flagged, and then excluded from processing in order to minimize the impact on the final product. For instance, occurrences of abnormal discrepancies between the wind speed obtained from the nadir beam data and the model have been resolved.

With the previous issue of the product, wave spectra were masked for azimuthal bins around the along-track direction. This was because of physical noise, namely speckle noise, observed along the track. Work was carried out to better account for this noise in all directions, so that processing can now deliver and exploit the whole spectra. This has improved wave parameters – significant wave height, direction and wavelength – which are now derived from the whole wave spectrum. A comparison with model data such as MFWAM shows good consistency for wavelength and direction, and highlights the advantages of SWIM products for wave characterisation. Concerning the significant wave height derived from wave spectra, some bias still exists, with overestimation at low values and underestimation at high values.

However, the areas for improvement have already been identified. A first upgrade may be applicable for the reprocessing of SWIM data planned for the end of this year.



CFOSAT SWIM wave parameters versus MFWAM wave parameters (2019 september 10th to 13th). Credits CNES.

SARAL/AltiKa level-2 cryosphere products

CNES, CLS Amandine Guillot, Jérémie Aublanc

SARAL (Satellite with Argos and AltiKa), is a CNES/ISRO satellite radar altimetry mission launched in 2013. The mission's main goal is ocean topography, so there is no operational product or processing dedicated to ice-sheet and sea-ice surfaces.

Nevertheless, the SARAL orbit covers high latitudes of up to +/-81.5°, providing valuable information on the Earth's polar cryosphere.

Compared to other conventional LRM altimetry missions, the AltiKa on-board altimeter offers several major innovations:

- **It is the first Ka-band altimeter (35.75GHz) ever flown onboard a satellite**. Ka-band radar wave interacts with snow in a different way to Ku-band, owing to the difference in signal wavelength (0.84 cm in Ka-band / 2.21 cm in Ku-band). In Ka-band, the signal penetrates less deeply into the snowpack, so the measurement is less sensitive to volume scattering than in Ku-band. Significant potential exists for using synergies between Ku/Ka measurements to derive snowpack properties and parameters, such as snow depth over sea-ice.
- **The altimeter has a higher bandwidth (480 MHz) than other altimetry missions (320 MHz).** AltiKa therefore has better vertical resolution (~31 cm compared to ~47 cm for the other missions), meaning that the on-ground surface is more finely sampled. For that reason:
    - **The radar footprint is also smaller** (diameter of ~11 km for SARAL, compared to a diameter of ~15 km for Envisat / Sentinel-3 / CryoSat-2).
    - **The shorter decorrelation time of sea echoes at Ka-Band** enables a higher pulse repetition frequency (4 KHz instead of 2 KHz in Ku-band) for better along-track sampling (40 Hz instead of 20 Hz).

Several papers already described the benefits and scientific applications of SARAL/AltiKa (Bonnefond et *al.*[2018] ; Verron et *al.* [2018]).

Ice sheet

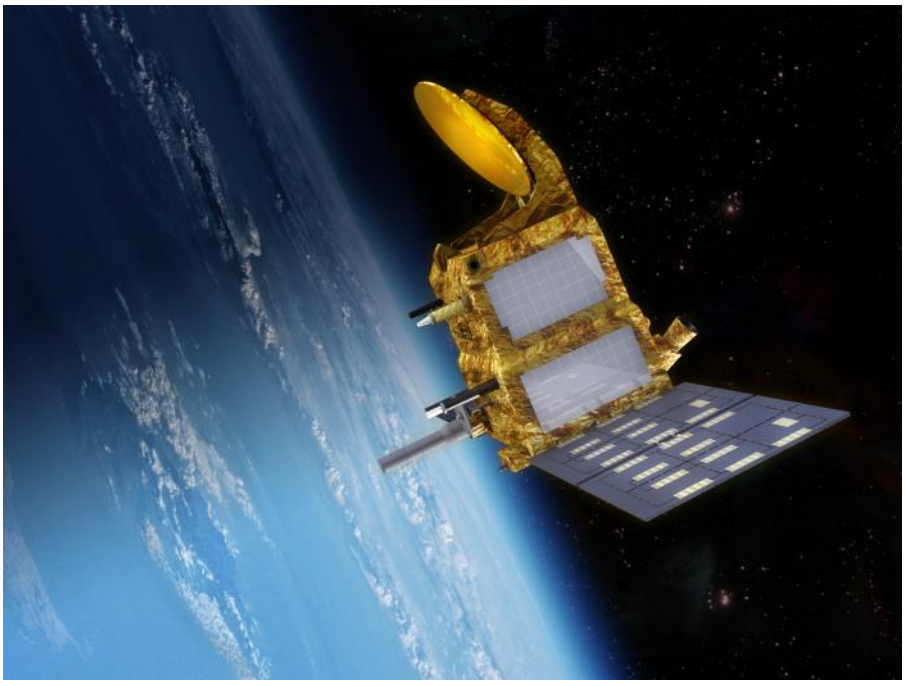
The dataset generated covers the Antarctica and Greenland ice sheets, over a period of one year: from 22 October 2018 to 11 November 2019 (cycles #124 to 134).

S-GDR + IceSheet is an R&D product packaged with operational S-GDR products. All the fields available in S-GDR are also available in the S-GDR + IceSheet product, along with extra fields.

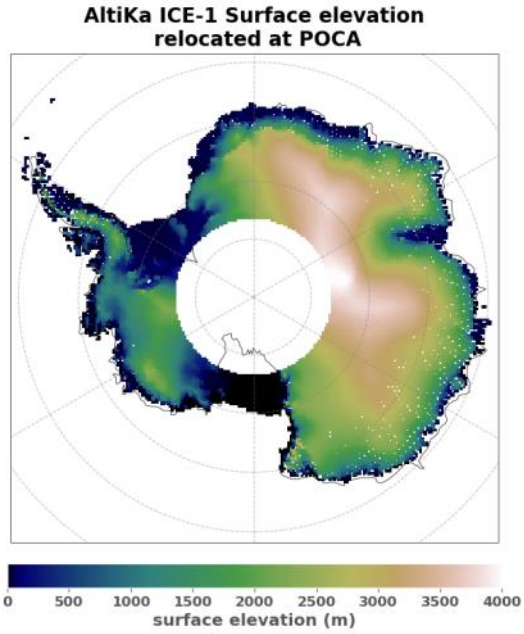
The additional fields are as follows:

- measurement relocation at Point Of Closest Approach (POCA),
- estimation of the ice sheet elevation (using ice1 retracking) relocated at Point Of Closest Approach,
- a surface type flag to differentiate between the ice sheet, ice shelves, bedrock and ocean,
- waveform classification,
- nadir surface elevation and topographic slope from an auxiliary Digital Elevation Model,
- a specific flag to edit AltiKa mispointing events.

More details on these fields, and the associated algorithms, can be found in the "Saral/AltiKa IceSheet product User Handbook".



Artist view of the Saral satellite, with the AltiKa altimeter over the top. Credits CNES.

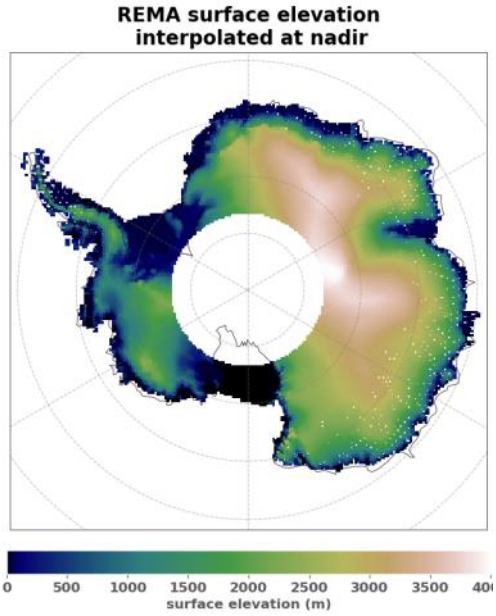


Antarctic surface elevation computed and gridded from 20Hz ICE-1 relocated estimations, acquired between May 20th and June 24th, 2019. Grid resolution is 25km. Credits CLS/CNES.

Results

To illustrate the products generated, the left map shows the computed Antarctic surface elevation (relocated at POCA), between 20 May and 24 June 2019, with a resolution of 25 km.

When compared to the reference DEM REMA (right map) interpolated at nadir satellite positions, the surface elevation geographical patterns look very similar.



Antarctic surface elevation from the Reference Elevation Model Of Antarctica (REMA), interpolated and gridded along AltiKa tracks. Grid resolution is 25km. Credits CLS/CNES.

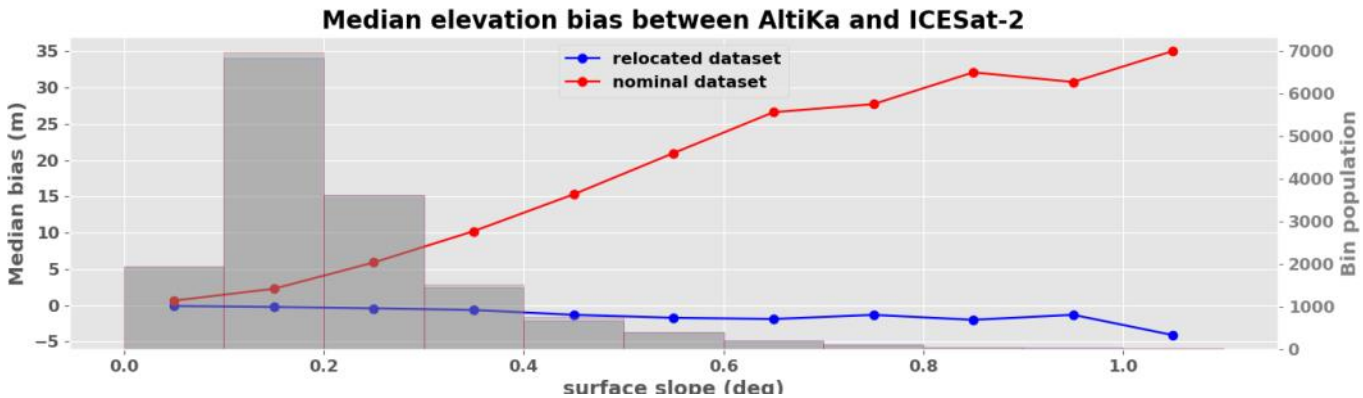
To validate the computed surface elevation provided by the ice-sheet products, data were compared to IceSat-2 ATL06 elevations at crossover points, by selecting the measurements located at a maximum 50m from each other (see figure below). Only the "valid" (see the handbook for the criteria applied) SARAL/AltiKa waveforms were taken into consideration for the statistics, resulting in the plot below, based on roughly 15,000 crossover points over Greenland between 20 May and 24 June 2019.

The elevation bias between AltiKa and ICESat-2 was analysed as a function of the surface slope. The red curve corresponds to the surface elevation from ICE-1 retracking at nadir, from the original GDR product (with no slope correction). The blue curve corresponds to the relocated surface elevation from ICE-1 retracking, from the ice sheet product. This plot clearly shows the improvement in the surface elevation estimated from AltiKa following relocation of the measurement.

The same validation exercise was carried out for ICESat-2 over the Antarctica ice sheet, leading to the same consistent results.

Links to download

See the SGDR+ Ice Sheet products on the AVISO+ website.



Surface elevation bias between AltiKa and ICESAt-2 ATL06 estimations, computed over the Greenland ice sheet at crossover points and represented as function of surface slope. Bias is computed using AltikA nominal S-GDR dataset (red) and S-GDR + IceSheet dataset (blue). Credits CLS/CNES.

SLA Arctic

CNES, CLS Amandine Guillot, Pierre Prandi

Much remains to be learned about the Arctic sea level (SL). Satellite radar altimetry is hindered by time variations in the sea ice cover. SL observations are useful not only to gain a clearer understanding of the ocean processes involved in this area of key importance for the climate, but also to validate and constrain ocean models.

In situ means such as tide gauges are mainly located along the Scandinavian coasts, and so do not measure the sea level of basins. Radar altimetry satellites make it possible to measure the sea level of the Arctic basin and over the open ocean, as well as over the sparse and small ocean areas appearing in cracks in the sea ice, known as "leads".

A CNES/CLS study built an Arctic Sea Level Anomaly (SLA) gridded product, combining a number of contemporary missions (CryoSat-2, SARAL/AltiKa, Sentinel-3A) to improve time and spatial resolution. The product also ensures processing continuity between the ice-covered and open ocean, which is required for assimilation into ocean models. The result of this study is a set of four gridded sea level products covering the open and ice-covered Arctic Ocean:

- **three mono-mission products**, one for each satellite CryoSat-2, SARAL/AltiKa and Sentinel-3A,
- **a multi-mission product** combining these three altimeters through an optimal interpolation scheme.

All products are in NetCDF format, and their characteristics are summarised in the table below. All of them are freely available from product sheet on AVISO+ siteweb.

Processing overview

A detailed description of the processing steps is available in two technical notes drafted for mono-mission (technical note) and multi-mission products (technical note). Briefly, the processing steps are the following:

- waveform retracking (adaptive retracker applied on SARAL/AltiKa, TFMRA applied on CryoSat-2 and Sentinel-3),
- ocean measurement selection (leads + open ocean), based on a neural network classification algorithm,
- SLA computation based on the application of geophysical corrections,
- data editing (hooking effect, outlier removal, smoothing),
- gridding (box-average) using the EASE2 standard.

The multi-mission product starts from the along-track SLA rather than the mono-mission grids. The main steps are:

- cross-calibration between the missions to guarantee consistency; SARAL/AltiKa is taken as the reference, since the physical retracker used ensures sea level continuity between the ice-covered and open ocean,
- filtering and subsampling of open ocean data at 5Hz,
- optimal interpolation computation (on EASE2 grid).

Results

Figure 1 and Figure 2 (see next page) show sea level anomaly maps around 20 February 2017 from mono-mission products and from the multi-mission product.

A large-scale analysis of the sea level anomaly maps shows that all missions see consistent large-scale features and are able to capture typical features of Arctic Ocean circulation, such as the Beaufort Gyre.

Products	Time period	Spatial coverage	Resolution	Time sampling
CryoSat-2	2010/07/30 - 2018/12/25	SAR mode mask	Monthly, 75km grid	10 days
SARAL/AltiKa	2013/03/28 - 2018/12/27	Latitude > 50°N	Monthly, 75km grid	10 days
Sentinel-3A	2016/07/15 - 2018/06/15	Latitude > 50°N	Monthly, 75km grid	10 days
Multi-mission	2016/07/01 - 2018/06/30	Latitude > 50°N	25km grid	3 days

Characteristics of the SLA products on the Arctic, monomission and multimission. See details on the product sheet on AVISO+ siteweb.

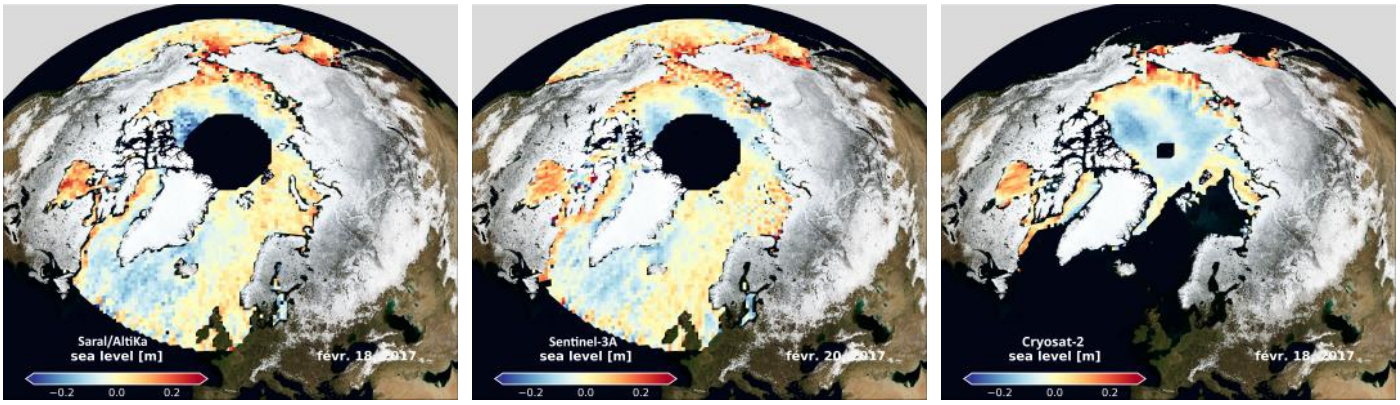


Figure 1, sea level anomaly maps around 20 February 2017 from SARAL/AltiKa, Sentinel-3A and CryoSat-2. Credits CNES/CLS.

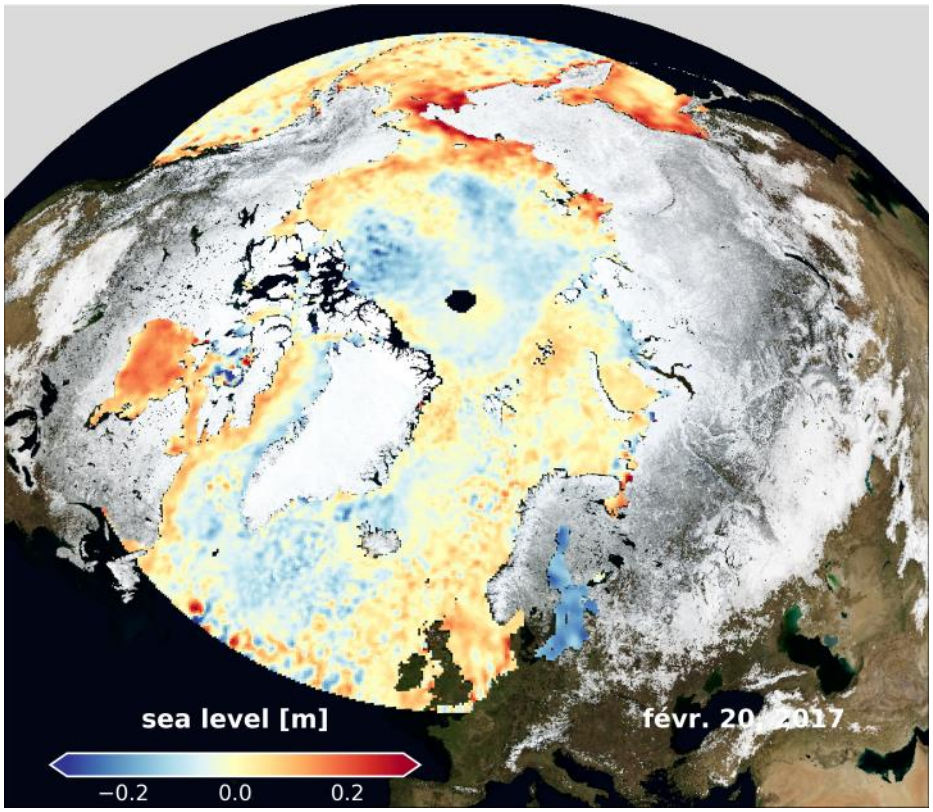


Figure 2, sea level anomaly map on 20 February 2017 from the multi-mission analysis. An animation over the entire multimission period (07/2016—06/2018) is available on the product sheet on the Aviso+ website.
Credits CNES/CLS.

The combined product benefits from the current altimeter constellation and shows improved resolution in both time and space, as shown on Figure 2, for the same date.

Quantifying the effective resolution of multi-mission products is not easy, but comparisons with the few tide gauges available in the basin provide valuable insights. At Prudhoe Bay station for example, the multi-mission product is able to capture high frequency SLA variability that is

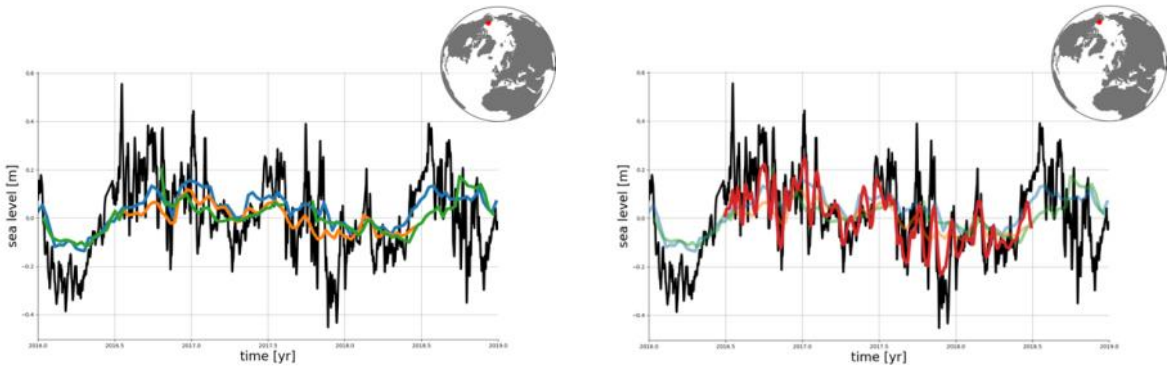


Figure 3, SLA time series at Prudhoe Bay (Alaska) with Sentinel-3A in orange, Saral/altiKa in blue and CryoSat-2 in green. The tide gauge record is in solid black. The left-hand panel shows a comparison with mono-mission altimeter records (solid colour). The multi-mission record is superimposed (solid red) on the right-hand panel. Credits CNES/CLS.

Inland water observation by satellites and the general public

Nicolas Picot, CNES, Jean-François Créteaux, LEGOS

Financed by the Adour-Garonne Water Agency, and with the technical support of CNES, the *"Observations des Eaux continentales par des Citoyens et des Satellites*" (OECS)* the Citizen Scientist project is now under way.

The project's objective is to promote a "Citizen Scientist" approach in the region managed by the Adour Garonne Water Agency, in order to raise public awareness of water-resource issues. Using a measuring system accessible to everyone – **water level gauges on lakes & rivers** – it aims to raise local awareness of the regional impacts of climate change as regards the natural resources available, including water stocks. This project is based on an American initiative, the LOCSS project, headed up by T.Pavelsky (SWOT/NASA PI (Principal Investigator) with the contribution of J.F.Crétaux (SWOT/CNES PI) in France.

To date, this equipment has been installed on twelve lakes in the Pyrenees (see Green Flags on the map) as part of the LOCSS project, with many measurements collected on the lakes every day.

As part of the OECS project, 50 gauges will be put in place in the region managed by the Adour-Garonne Water Agency (see Blue Flags on the map), in close collaboration with the local stakeholders concerned (rowing clubs, water-sports bases, fishing federations, associations, secondary schools, etc.) and in synergy with the measurement points covered by the various satellites (in particular the SWOT mission). This project will play a particularly valuable role in validating the satellite data concerning these hydrological surfaces, whether from the Sentinel-3A/B or Jason-3/Jason-CS satellites or the future French-American SWOT satellite, which will take daily measurements across this region in 2022.

Example of a gauge installed in a lake in the Pyrénées by Principal Investigator J.F. Crétaux. Credits J.F. Crétaux, LOCSS

Region managed by the Water Agency, SWOT 1-day orbit swath, Green Flags: sites equipped on the lakes in the Pyrénées, Blue Flags: Water Sports Bases under 1-day orbit. Credits J.F. Crétaux, LOCSS.

* OECS means in English "Observation of in land water by citizens and satellites".

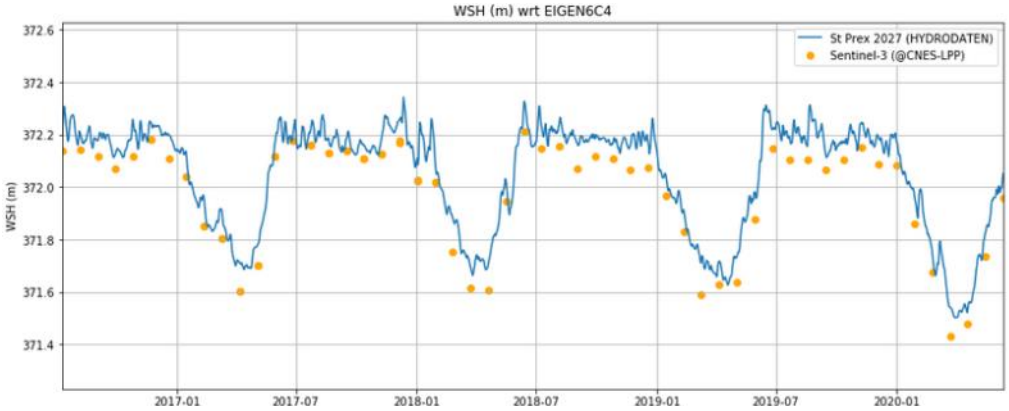
Innovative processing of Sentinel-3 lake data

François Boy, CNES

To prepare the SWOT mission, CNES is developing a specific method for processing Sentinel-3 SAR data concerning lakes. The aim of this initiative is to establish the water levels of the lakes passed over by the Sentinel-3&6 constellation with a high degree of accuracy, in order to compare data with the SWOT mission during the CAL/VAL (calibration and validation) phase.

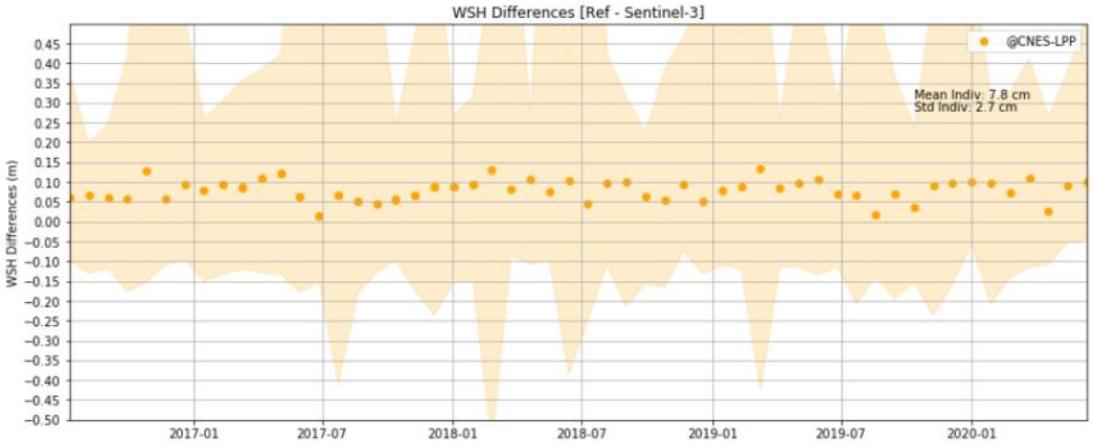
Since current operational processing methods only partially exploit the significant potential of SAR data, CNES has developed a prototype devoted to data acquired on lakes, using an innovative approach. The idea is to simulate radar data based on lake contours and to adjust the surface characteristics according to the radar data acquired in order to obtain an accurate water level. The algorithm is currently being validated through a comparison with data from the hydrometric stations operated by the Swiss Federal Office for the Environment. In the example provided, the comparison between the water levels measured by the Sentinel-3A mission and by the Saint-Prex station on Lake Geneva, shows excellent consistency, with a radar measurement accuracy of 3cm RMS. Many other cross-checks are in progress, on Swiss lakes and also on small reservoirs (a few hundred meters wide) in the Occitanie region of south-west France. These initial results show that the accuracy is comparable whatever the size of the hydrological target observed (between 3 and 6 cm RMS).

Ground track of the Sentinel-3A orbit, Lake Geneva. Credits Google Earth.



***Blue**: water level of Lake Geneva measured by the Saint-Prex hydrometric station. **Orange**: water level measured by the Sentinel-3A mission based on the prototype developed by CNES. Credits: F. Boy, CNES.*

***Orange**: differences between Sentinel-3A measurements and data from the hydrometric station on Lake Geneva.*



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ESA Grid Processing on Demand (G-POD) for Earth Observation Applications

New upgrades to OLTC tables onboard nadir altimeters used in hydrology in 2020

CNES, Sophie Le Gac, Denis Blumstein

On Jason-3 and Sentinel-3 altimeters, a dedicated onboard memory is used to command the acquisition window of the signal reflected by the surface. The **Open-Loop Tracking mode** (OLTC) is the nominal operating mode over oceans and over most continental surfaces. In hydrology, the success of this mode (more than 90% success in Open-Loop mode compared to about 50% in Closed-Loop mode) resides in the quality of the Digital Elevation Model (DEM) used to set the echo reception window.

Following the last OLTC updates on Jason-3 (31 August 2017), Sentinel-3B (27 November 2018) and Sentinel-3A (9 March 2019), further achievements have been reported in hydrology, such as the measurement of narrow rivers in France for the first time using altimetry. Since then, much work has been engaged to continuously improve the precision of onboard DEMs and pursue the densification process (addition of numerous water bodies, including smaller lakes and narrow rivers worldwide).

For this purpose, the CTOH and ECHOS teams worked with LEGOS and CNES teams as well as other expert users, combining their technical and scientific expertise to further enhance the capabilities of nadir altimeters and supply new data for the entire hydrology community.

In 2020, this work came to fruition with the upgrade of all our current OLTC tables, now covering over 30,000 water bodies for Jason-3 and over 70,000 for both Sentinel-3 altimeters. The Table shows details of the number of water bodies defined in these OLTC tables.

All uploads were successfully completed by CNES and its partners and validation of the hydrology data acquired is now under way.

Sentinel-6 will also benefit from the same onboard DEM as Jason-3, heralding an interesting phase of commissioning phase and tandem operation with Jason-3.

We believe this work makes a useful contribution to the progress of both the altimetry and hydrology communities, making valuable data available to users, in preparation for SWOT.

Mission	OLTC version	Date of activation	Number of hydro targets (total)	Number of hydro targets by type : rivers / lakes / reservoirs / glaciers*	Geographical area covered Open-Loop mode over land
Jason-3	V3.0	August 31, 2017	4,721	4,366 / 355 / - / 0	Global
Sentinel-3B	V2.0	November 27, 2018	32,515	17,016 / 14,245 / 1,231 / 23	|lat|<60°
Sentinel-3A	V5.0	March 19, 2019	33,261	17,409 / 14,427 / 1,386 / 39	|lat|<60°
Sentinel-3B	V3.0	June 18, 2020	73,629	21,719 / 47,738 / 4,419 / 23	Global
Sentinel-3A	V6.0	August 27, 2020	74,050	20,100 / 47,637 / 4,262 / 51	Global
Jason-3	V4.0	September 3, 2020	31,473	8,602 / 21,393 / 1,478 / 0	Global

Description of current and past OLTC tables on Jason-3, Sentinel-3A and Sentinel-3B (adapted from Taburet et al. (2020).

**identified as such for OLTC definition*

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AVISO+ website, operational after a cyber-attack

Laurent Soudarin, CLS

Since its launch, the Aviso+ website has been the portal for altimetry (and DORIS) data. Set up for purposes of dissemination, information and promotion, it provides thousands of users with free access to high-quality products generated by CNES and its partners. It is in no way a commercial service and does not distribute sensitive data. However, it recently experienced a cyber-attack.

On June 1 2020, we discovered a malicious intrusion, which was immediately neutralized. Thanks to the security measures in place, no damage was observed and no data were recovered by the attacker.

However, as a precautionary measure, we had to close the website until mid-July. This did not impact the data distribution services, which remained open.

We used this shutdown period to investigate the attack and strengthen security.

The website was reopened on July 17, proving fresh access to all the data, articles, news and tools available on Aviso+, enabling users to discover altimetry or to improve their skills in this field. However, some features were still inactive, including the registration form. **From October 19, new users are once again be able to register for the Aviso service**. We apologize for any inconvenience caused during this period and are pleased to have the Aviso+ website **fully operational** once again.

Coastal altimetry in Toulouse -

Long-term observations of the sea level in increasing proximity to coastal areas.

Florence Birol, LEGOS, Mathilde Cancet, NOVELTIS

Thanks to all the work and studies carried out over the last fifteen years or more, space altimetry now provides increasingly usable measurements of coastal ocean areas, opening the door to new applications and/or the potential integration of these data in coastal marine observation systems. At a time when many changes are being observed in coastal marine areas, these space altimetry observations will also play a fundamental role in monitoring and forecasting coastal sea level changes on a global level.

In the Toulouse area, various organisations (CNES, research laboratories, SMEs) have acknowledged expertise and a long history of projects in this field (PISTACH, PEACHI, X-TRACK, ESA CCI SL, etc.). Today, major coordination initiatives are under way to build a network bringing together all the available skills and users in the area, driven and supported by CNES. The project's objective in 2020 is to precisely identify the technical and scientific hurdles, and to map out the needs. In early 2021, a joint roadmap of the work to be carried out will be established, in order to deliver new coastal altimetry products that meet the needs of the applications identified in the project. From the end of 2021, regular open thematic workshops will be organised, bringing together processing experts and users. These workshops will allow the products and tools developed as part of the project to be tested and validated in a short loop before being distributed more widely.

Events

October 19-23, 2020 Virtual meeting, Ocean Surface Topography Team Meeting

November 17-19, 2020 (POSTPONED), Saint-Malo, France, CFOSAT Science Team meeting

December 01-17, 2020 San Francisco, CA, USA, AGU Fall Meeting

March 16-18, 2020 Saint-Malo, France, CFOSAT Science Team meeting

April 25-30, 2021 Vienna, Austria, EGU General Assembly

May 25-27, 2021 Virtual symposium, 2nd Operational Satellite Oceanography Symposium

October 18-22, 2021 Venice, Italy, Ocean Surface Topography Team Meeting and IDS workshop

AVISO+ Users Newsletter

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