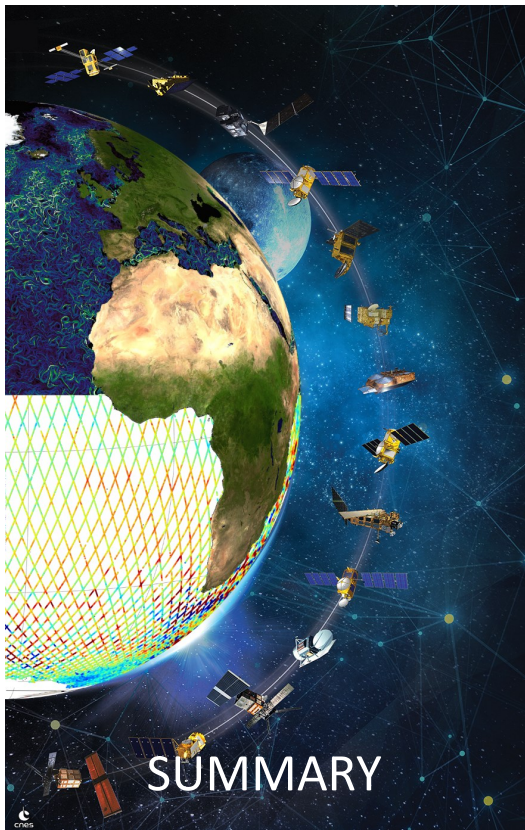




#16

December 2019

Users Newsletter



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Project news

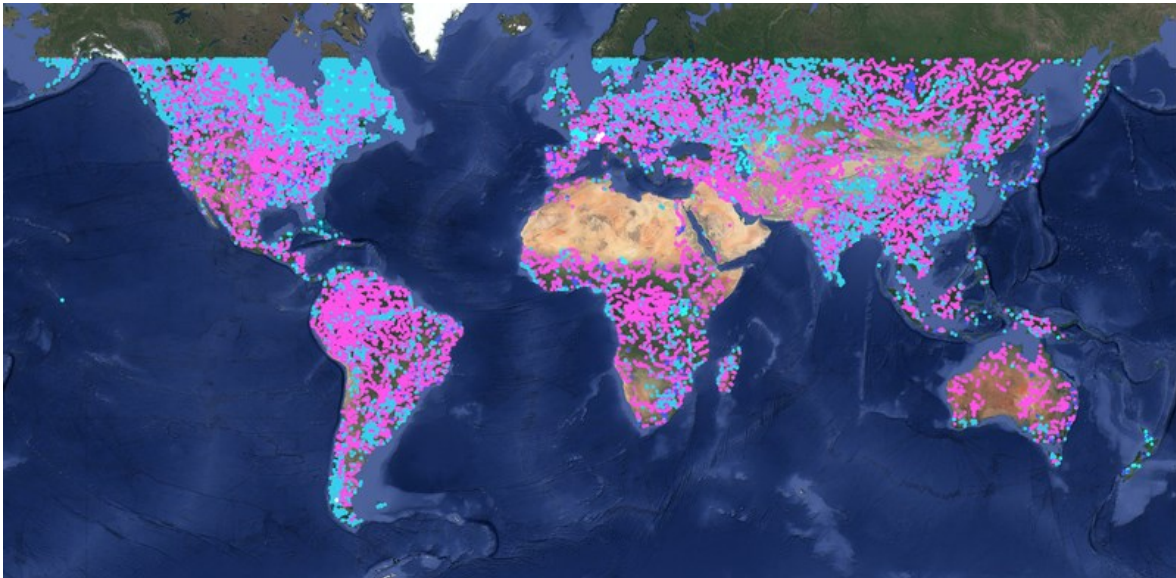
CNES, Nicolas Picot, Thierry Guinle and project managers

The virtual altimeter constellation currently includes eight operating satellites. Few months ago, the total number was nine and it was the first time that such a high number of altimeter satellites were operational at the same time. Since last [AVISO+ newsletter](#), the Copernicus Sentinel-3B satellite, HY-2B and CFOSAT have been launched and successfully passed their respective in orbit commissioning phase. During the same period, OSTM/Jason-2 mission was decommissioned. This particularly high number of altimeter satellites in orbit opens the room for dedicated analysis related to ocean mapping, regional products etc.

Sentinel-3 is an European Commission mission designed to measure sea surface topography, sea- and land-surface temperature,

and ocean- and land-surface color. Sentinel-3 is one of a series of missions, each covering a different aspect of Earth Observation and monitoring. Sentinel-1 is a SAR-dedicated satellite while Sentinel-2 is carrying an optical payload. [Sentinel-3A](#) was launched on February 27, 2016 and is currently in nominal operation, handled by ESA and EUMETSAT. [Sentinel-3B](#) was launched in April 2018 with a Rockot launcher and has successfully achieved its commissioning phase end 2018. After the tandem with its twin [Sentinel-3A](#) (30 seconds ahead, corresponding to ~223 km) which provided a very important data set to insure the homogeneity between both missions and as well a very useful data set to support specific studies, [Sentinel-3B](#) has been placed on its operational orbit in November 2018. The altimeter has also been





Virtual stations defining lakes, reservoirs, rivers and even glaciers worldwide uploaded with new Open-Loop Tracking Command (OLTC) tables, on-board Sentinel-3A and Sentinel-3B. Credits CNES.

uploaded with new Open-Loop Tracking Command (OLTC) tables, which are used to control the return echo acquisition phase of the altimeter by setting its reception window. This on-board process ensures recording reliable and quality measurements over inland waters. These tables have been upgraded with more than 32,500 virtual stations defining lakes, reservoirs, rivers and even glaciers worldwide, as shown on the featured image (see above). A similar update occurred for **Sentinel-3A** mid-March 2019. Combined with **Sentinel-3B** this provide a unique coverage of inland water bodies as more than 65,000 inland water targets have been included in the on-board tables. A few glaciers were also included during this major evolution to test and demonstrate the capacity of nadir altimeters to track those fast changing areas. While extending the capability of both **Sentinel-3A and B** satellites, ESA continues to work on the Sentinel-3C&D development.

CFOSAT, the Chinese-French oceanography mission operated by CNES and CNSA, is devoted to ocean surface wind and wave observation. The satellite was launched on October, 28th 2018 and has successfully passed its in

orbit validation phase. The data will be soon freely accessible for scientific purposes.

Launched in January 2016 **Jason-3** satellite remains the reference mission for the AVISO+ and CMEMS DUACS system.

Few months after its 11 years anniversary in orbit, **Jason-2** satellite encounters major issue on the power management system and forced CNES and its partners (NASA, JPL, EUMETSAT, NOAA) to complete the mission. This occurred on October 1st 2019 with a final passivation of the spacecraft on October 10th from the CNES Control Center in Toulouse. Up to that date, **OSTM/Jason-2** mission provided the altimetry community with high-quality products. The last two years of the mission (from July 2017 and the move to a Long Repetitive Orbit (LRO) at an altitude of roughly 1309.5 km) were dedicated to geodetic purposes. With the choice of the LRO (and then interleaved i-LRO), Jason-2 coverage and products quality were excellent both for operational applications and science usage.

The French-Indian **SARAL** mission is being operated by CNES and ISRO (the Indian Space Research Organization) with the participation

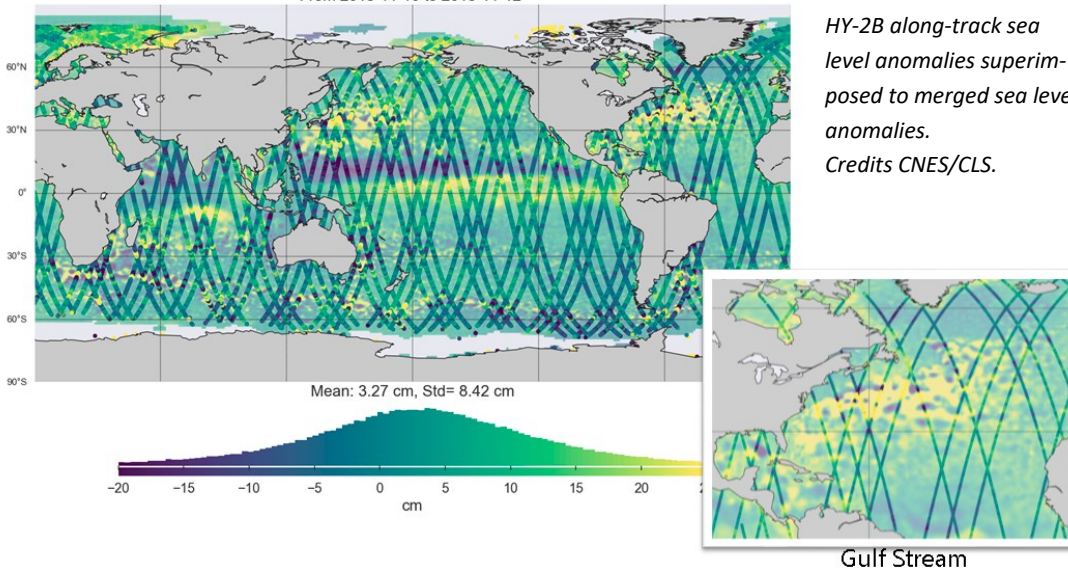
of EUMETSAT. SARAL was launched on February 25, 2013. Early 2019, SARAL encounters some issues affecting the nadir pointing accuracy. The situation was improved by ISRO team mid-April thanks to new operational procedures. However, the availability and the quality of data measurements might be degraded from time to time and users should remove any ocean data with "off_nadir_angle_wf" over 0.09 deg². SARAL mission is officially planned to continue up to end of 2021.

HY-2A and **HY-2B**, launched respectively in August 2011 and October 2018, are Chinese missions with French-Chinese collaboration between CNES and CNSA/NSOAS for altimetry (DUACS) and orbitography products (IDS). On March 23, 2016, the **HY-2A** satellite was moved from its nominal orbit to 2 km higher. The new orbit has a 168-day cycle with 2,315 orbits in the full cycle. **HY-2B** data are planned for integration in DUACS/CMEMS products in 2020.

ESA's **Cryosat-2** ice mission, launched on April 8, 2010, also contributes to the multi-mission SSALTO/DUACS system as a complementary mission for value-added products (Levels 3 & 4).



Hy-2B Sea Level Anomaly passes (over MSLA)
From 2018-11-10 to 2018-11-12



HY-2B along-track sea level anomalies superimposed to merged sea level anomalies.
Credits CNES/CLS.

Cryosat-2 is expected to continue up to February 2021 at least, given that there is no sign of degradation on the platform at the moment. In 2018-2019, a global reprocessing of ocean data collected from April 2010 to the JPL team. In particular, the KaRIn Radio Frequency Unit Flight model is being tested in Thalès Alenia Space premises in Toulouse. It will be soon delivered by CNES for integration at JPL with the KaRIn instrument. The platform development is ongoing, and all equipments have been supplied. Launch date is expected to occur in September, 2021.

Three satellites (**SARAL**, **Cryosat-2** & **HY-2A**) are in a geodetic and/or LRO orbit, thus providing a very dense coverage of the ocean surface.

Ongoing developments

SWOT (Surface Water and Ocean Topography) is a French-American mission run jointly by CNES and

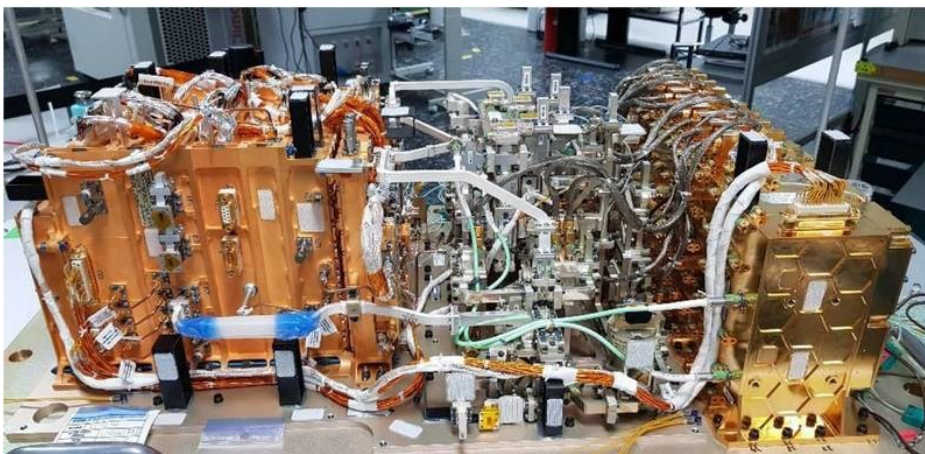
NASA, with the participation of UKSA and CSA, to study oceanic and inland water surfaces. Mission progress is nominal, with the first deliveries of the CNES flight models to the JPL team. In particular, the KaRIn Radio Frequency Unit Flight model is being tested in Thalès Alenia Space premises in Toulouse. It will be soon delivered by CNES for integration at JPL with the KaRIn instrument. The platform development is ongoing, and all equipments have been supplied. Launch date is expected to occur in September, 2021.

Between two concepts, **FORUM** and **SKIM** in competition for the ninth Earth Explorer mission, ESA has finally chosen **FORUM** during summer '19. This is a bad news for the Sea-surface Kinematics Multiscale monitoring (**SKIM**) which

objective was to increase our knowledge of how the ocean and atmosphere interact – for example, how atmospheric carbon dioxide is drawn down into the ocean. French project team is trying to find another opportunity to embark this innovative instrument.

Sentinel-6A/Jason-CS-A, 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, in November 2020. Also known as Jason Continuity of Service (Jason-CS), the Sentinel-6 satellites will replace the Jason-3 satellite to ensure the continuity of operational oceanographic services on the reference orbit beyond 2030. The development of this new generation of Jason satellites is ongoing according to plan.

CRISTAL is a new polar altimetry project. This mission is one of the 6 High Priority Copernicus Missions (HPCM). If this mission is selected, it will be able to extend the monitoring of the polar regions and the evolution of its oceans, sea ice and ice caps due to global warming. In addition to its near polar orbit (92°), the specificity of this mission is to carry a dual frequencies SAR altimeter that allows to measure the depth of the snow over the ice.



The SWOT KaRIn Radio Frequency Unit Flight model being tested on March 2019. Credits TAS.



First SWIM wave data on CFOSAT



CNES, Cédric Tourain

The French-Chinese **CFOSAT** satellite was launched on 28 October 2018 and the French wave radar, **SWIM**, was activated on November 1st.

Since then, the Calibration/Validation work has been carried out by teams from CNES, Latmos, IFREMER, LOPS, CLS and Météo-France. The work has enabled several adjustments to be made in on-board and ground processing. The on-board processing system was finally and successfully upgraded on 25 April 2019.

The first meeting of the **CFOSAT International Science Team** was held in Nanjing (China) from 23 to 25 September 2019. It was an opportunity for the project teams to summarize all the analyzes and observations made on the data of the French **SWIM** wave radar and the Chinese wind scatterometer **SCAT**. This meeting also provided the first

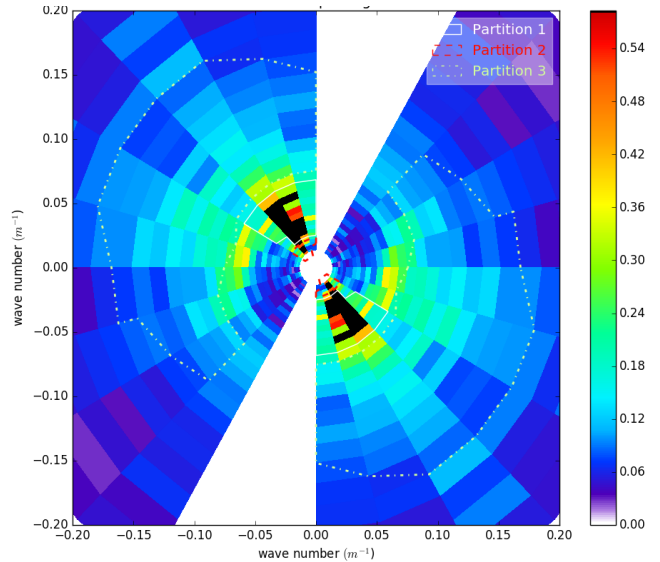
feedback from scientists on the product's quality of the two instruments. Dissemination of **SWIM** and **SCAT** products is planned by end of 2019 - early 2020.

Performances

The performance of the **SWIM** data products is very promising and confirms the great potential of **SWIM** data for oceanographic applications. The work will continue for the purpose of:

- characterising the performance more thoroughly;
- continuing to improve processing, particularly by taking into account and compensating the physical noise observed along the track;

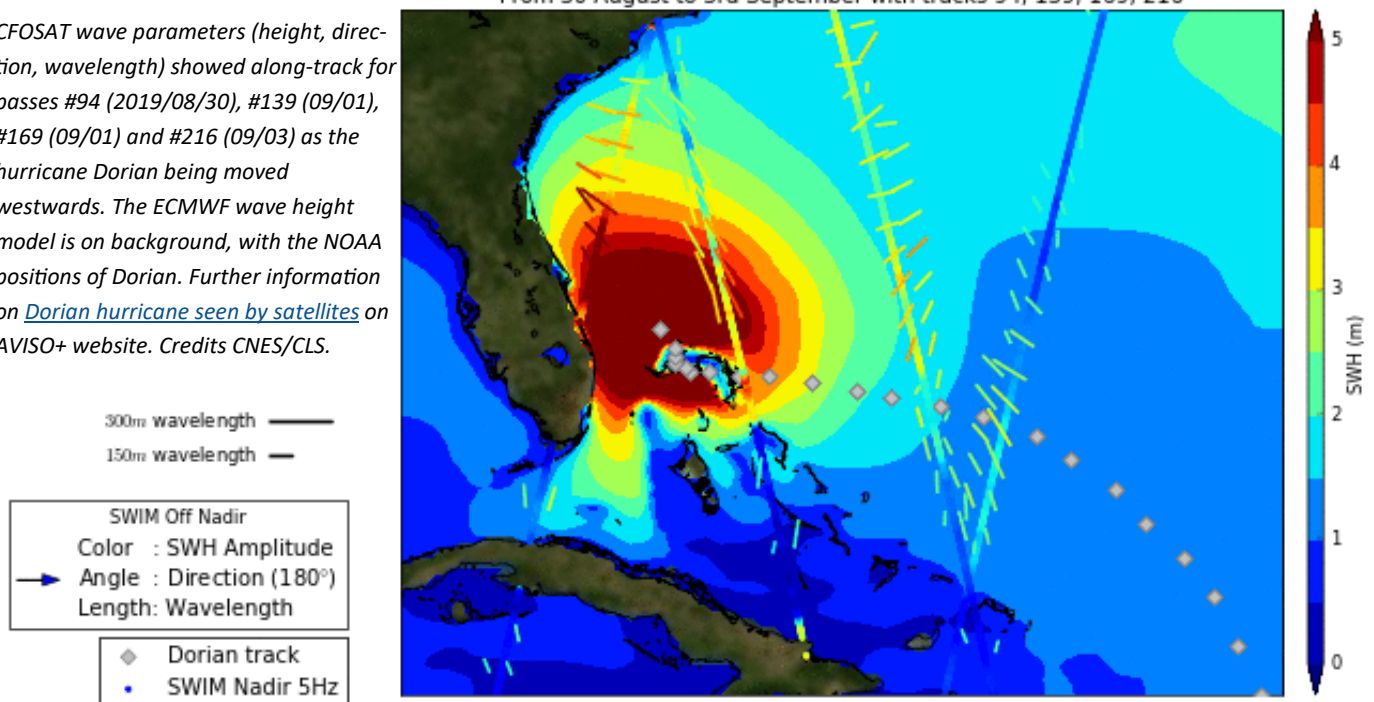
- exploring the possibilities for secondary applications (observations of sea ice, the cryosphere, land surfaces, etc.).



Mean wave slope directional spectrum along the CFOSAT track on September 3 along the hurricane Dorian's path. Wave parameters (height, direction, wavelength) can be deduced. Credits CNES/CLS.

CFOSAT wave parameters (height, direction, wavelength) showed along-track for passes #94 (2019/08/30), #139 (09/01), #169 (09/01) and #216 (09/03) as the hurricane Dorian being moved westwards. The ECMWF wave height model is on background, with the NOAA positions of Dorian. Further information on [Dorian hurricane seen by satellites](#) on AVISO+ website. Credits CNES/CLS.

SWIM SWH Off-Nadir Combined (Arrows) with Swim Nadir (Lines) From 30 August to 3rd September with tracks 94, 139, 169, 216





Sea surface height and derived products

- Monomission Corrected Sea Level Anomalies (L2P), **New : Sentinel-3B**
- Ssalto/Duacs experimental along-track and gridded Sea Level Heights and velocities, **New : gridded SLA dedicated to Arctic**
- 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: **Soon: Saral/AltiKa and T/P reprocessing**

Ocean indicators

- ENSO index & maps
- Mean Sea Level
- Kuroshio index
- Ionian Sea index

Value-added products

- Lyapunov exponents or Filaments
- Mesoscale eddy trajectory atlas **New: NRT**

Coastal – Ice – Hydrology products

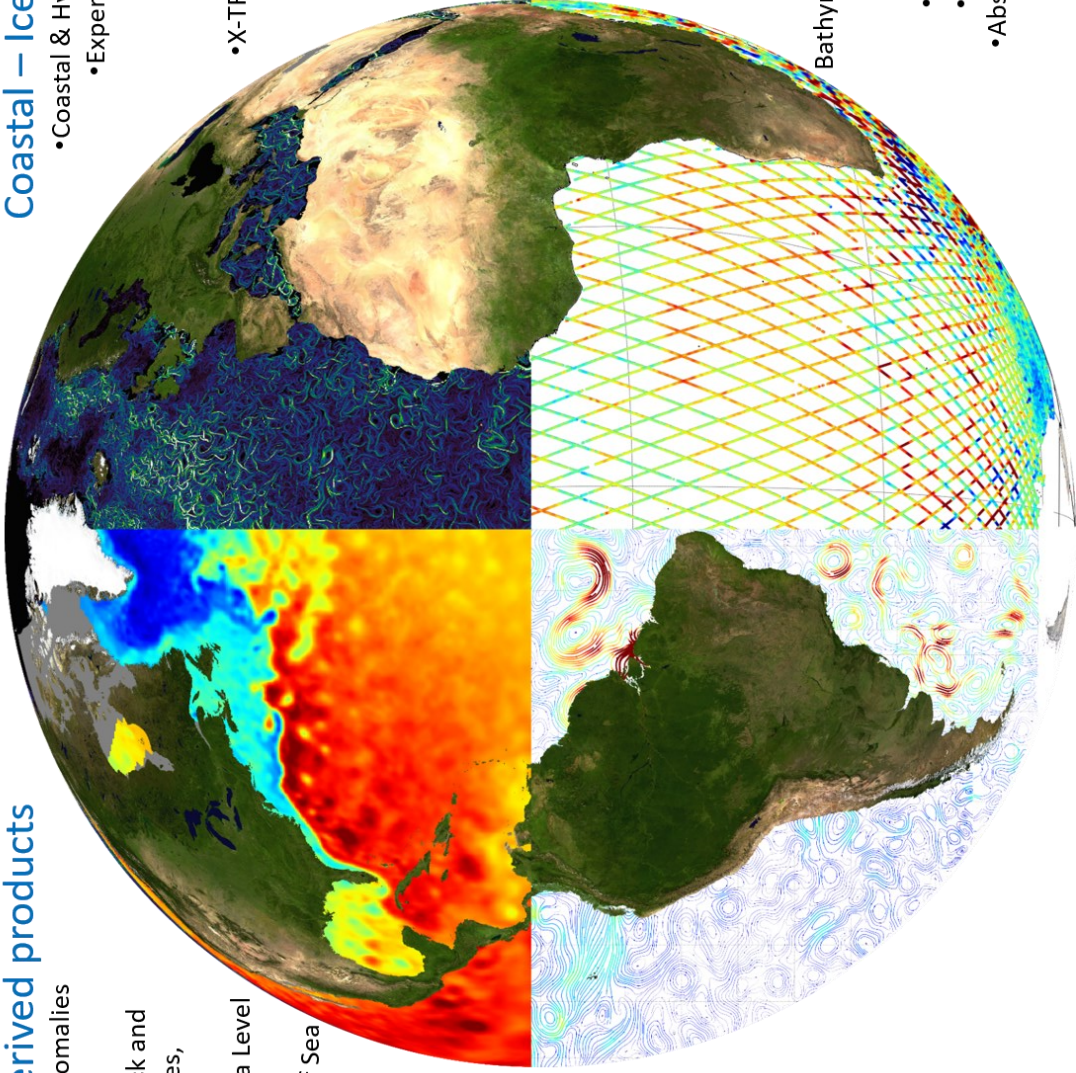
- Coastal & Hydrology Geophysical Data Records
- Experimental Geophysical Data Records: **Soon Sentinel-3A products**
 - Sea ice product: **Soon Alti Snow Depth + Antarctica**
- X-TRACK Coastal Sea Level Anomalies: **Soon new reprocessing**

Wave heights and wind speed

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

Auxiliary products

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



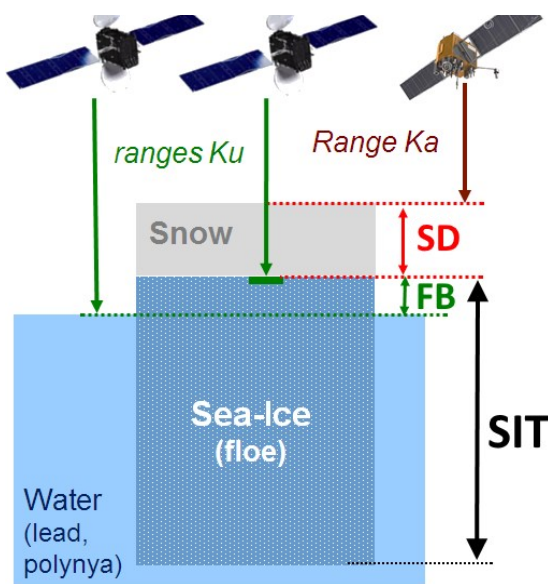
Altimetry data for sea-ice thickness and snow depth over Arctic and Antarctica



CTOH, Sara Fleury, Florent Garnier

The CTOH Sea Ice Thickness product has been updated with a longer time series up to 2019 over Arctic, including a new estimation of the snow depth, and soon the Antarctica coverage.

The Sea Ice Thickness using satellite altimetry product has been available through CTOH data access services since December 2017. A new version financed by the ESA CryoSeaN-ice and CNES TOSCA projects will soon be available to AVISO+ users.

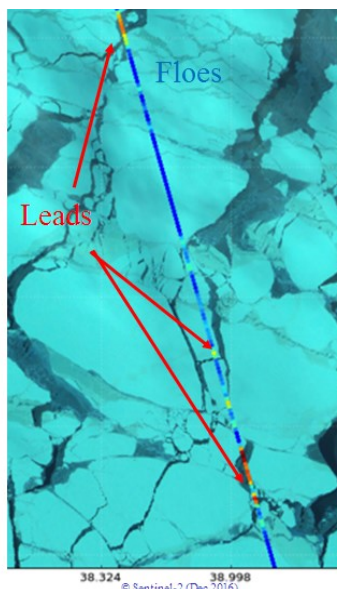


“Freeboard” method : It consists in calculating the height difference between the floes (range above the ice) and the leads (range above the water in ice fractures) . Credits CTOH.

Sea ice is a key indicator

Sea ice and its snow coverage has important effects on the global climate because of its albedo, which reflect solar radiations and limit water heating, and because of its insulation properties, which limit the exchanges between water and the atmosphere. The melting and freezing processes also modify the thermohaline circulation, and sea ice thickness and snow depth have an impact on primary production.

The survey of these high latitudes requires satellite altimeters with high latitude orbits. The **CryoSat-2** mission carries the only radar altimeter that covers nearly all the Arctic sea ice thanks to its 92° inclination. The satellite was launched in 2010 with the first SAR altimeter, which offered an unprecedented along-track resolution (~300 m) and the first exploitable sea-ice measurements. It was followed by **Sentinel-3 A** (launched on Feb. 2016) and **Sentinel-3B** (launched on April 2018), which



have similar performances but are limited to latitudes of up to 81.5°. **Saral/AltiKa**, launched on 2013, follows the same orbit but it operates in a higher Ka-band frequency which does not penetrate the snow unlike the usual Ku-band.

To complete this ongoing constellation, the **Envisat** data are used by recalibrating freeboards on the **CryoSat-2** solution using a polynomial relationship based on the intermissions freeboard differences and the surface roughness.

Sea Ice Thickness

Sea ice thickness (SIT) measurement relies on the “Freeboard” method. It consists in calculating the height difference between the floes (range above the ice) and the leads (range above the water in ice fractures) (see figure on left).

Alti Snow Depth

The difference of the scattering properties of the AltiKa Ka-band (on **Saral**) and the Siral Ku-band (on **CryoSat-2**) altimeters provides a good proxy of the snow depth using an adapted processing chain, **Alti Snow Depth (ASD)**.

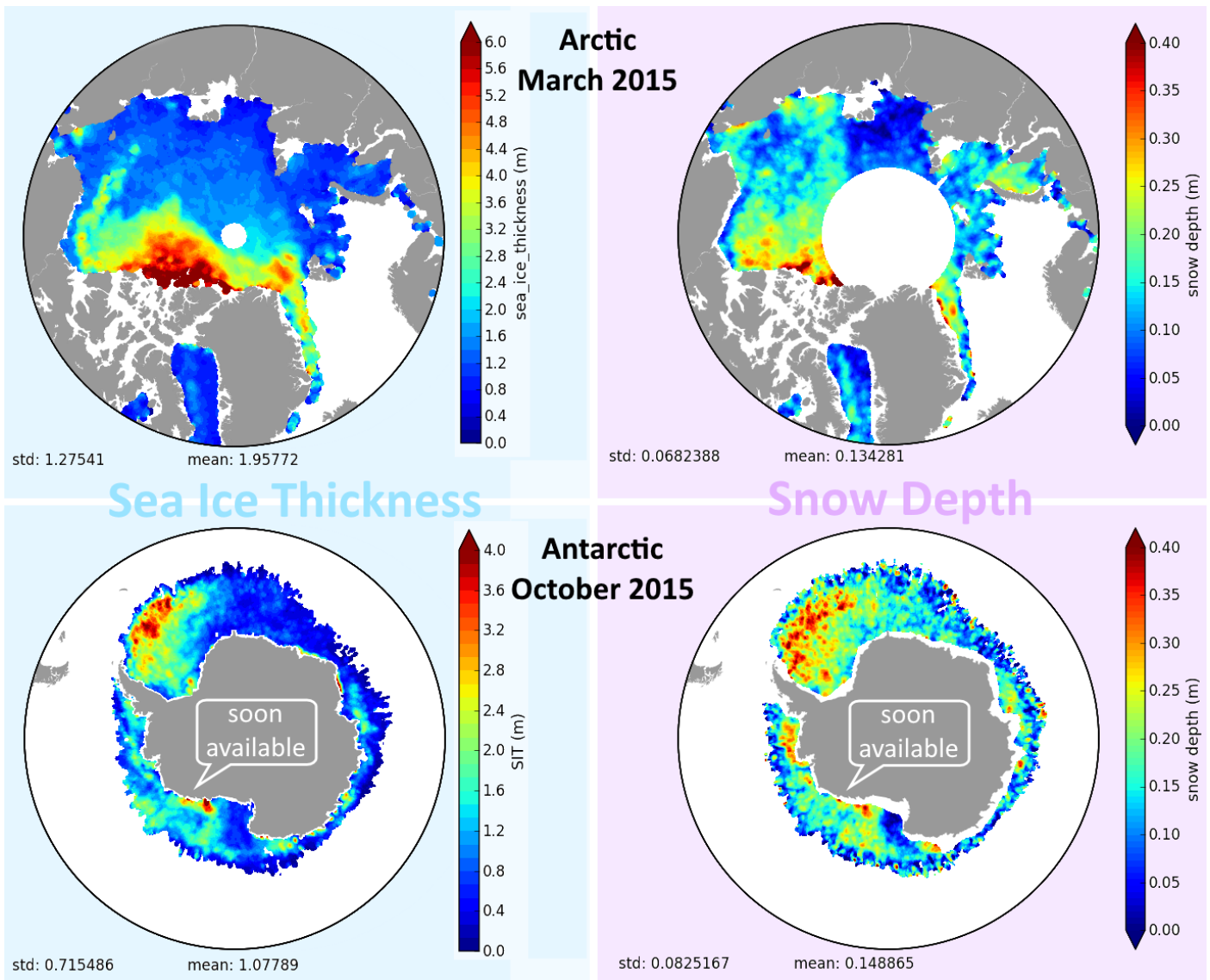
Antarctica

Compare to the Arctic Ocean, the sea ice thickness interannual variability in Antarctica is quite small, without significant positive or negative trends. But the lack of validation data prohibits to evaluate the uncertainties, and the availability of *in situ* data in a proper format becomes critical.

Future in sea ice

CRISTAL is a new polar altimetry project selected by European Commission, among the six High Priority Copernicus Missions (HPCM). If it is selected, it will be able to extend the monitoring of the polar regions and the evolution of its oceans, sea ice and ice caps due to **global** warming. Further information about CRISTAL: [Mickael Kern's presentation](#) during the last workshop dedicated to glaciology by altimetry, organized by CNES and LEGOS.





The right maps show the Snow Depth obtained by Ka/Ku difference over the Arctic (top) and over the Antarctic (bottom). From these Snow maps and the Sea Ice Freeboard measured with CryoSat-2-2 we can deduce the Sea Ice Thickness maps on the left. This example concerns the month of March 2015 for the Arctic and the month of October 2015 for the Antarctic. Credits CTOH.

In brief

Satellite altimeters	Covered region	Covered period	Main variables	Type
Envisat (EN) / CryoSat-2 (C2)	<u>Arctic:</u> EN: 65°N < lat < 81.5°N C2: 65°N < lat < 88°N <u>Antarctic:</u> 81.5°S < lat < 55°S soon	2002– 2019	Sea ice Freeboard Modified Warren Snow Depth for the Arctic AMSR Snow Depth for the Antarctic Sea Ice Thickness	L4 gridded L2P along-track soon
CryoSat-2 / Saral	<u>Arctic:</u> 65°N < lat < 81.5°N <u>Antarctic:</u> 81.5°S < lat < 55°S soon	2013—2019	Sea ice Freeboard Alti Snow Depth Sea Ice Thickness	L4 gridded
CryoSat-2	<u>Arctic:</u> 65°N < lat < 88°N soon	2010—2019	Sea ice Freeboard Modified Warren Snow Depth Sea Ice Thickness Sea Level Anomalies	L4 gridded L2P along-track soon

New CNES-CLS18 Mean Dynamic Topography



CLS, Sandrine Mulet.

A new global $1/8^\circ$ CNES-CLS18 Mean Dynamic Topography (MDT) with corresponding mean geostrophic currents has been produced and is now freely available for AVISO+ users.

The CNES-CLS18 MDT is based on 10.5 years of GRACE data and the entire set of reprocessed GOCE data (Nov 2009 to Oct 2013) as well as 25 years of altimetry data and 23 years of *in situ* data (drifting buoy velocities including Argo float surface velocities and hydrological profiles for the period from 1993 to 2016).

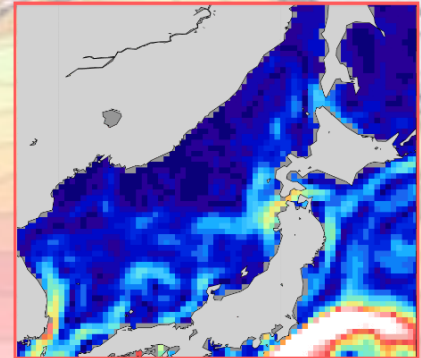
The reference period of this new MDT remains 1993 to 2012 which is consistent with CMEMS (M)SLA products from DUACS system.

The new grid resolution is $1/8^\circ$ (instead of $1/4^\circ$ for CNES-CLS13).

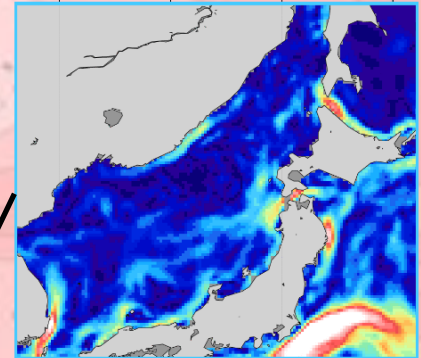
A comparison with independent datasets such as drifter velocities, SAR and ADCP show improved performances for the new CNES-CLS18 MDT compared to the CNES-CLS13 solution, most significantly for coastal areas and strong western boundary currents.

Further information on Aviso+ : [MDT CNES-CLS18](#)

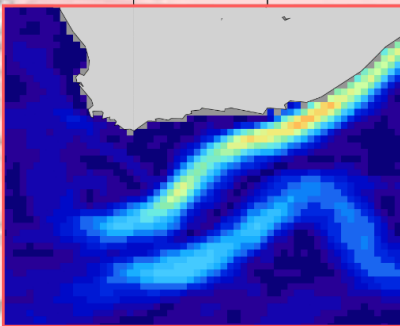
CNES-CLS13 MDT



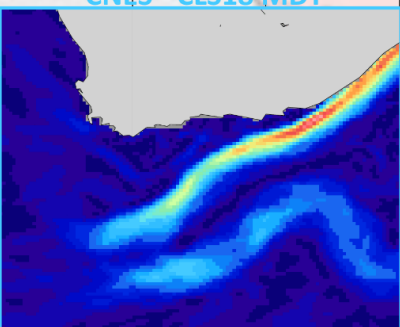
CNES-CLS18 MDT



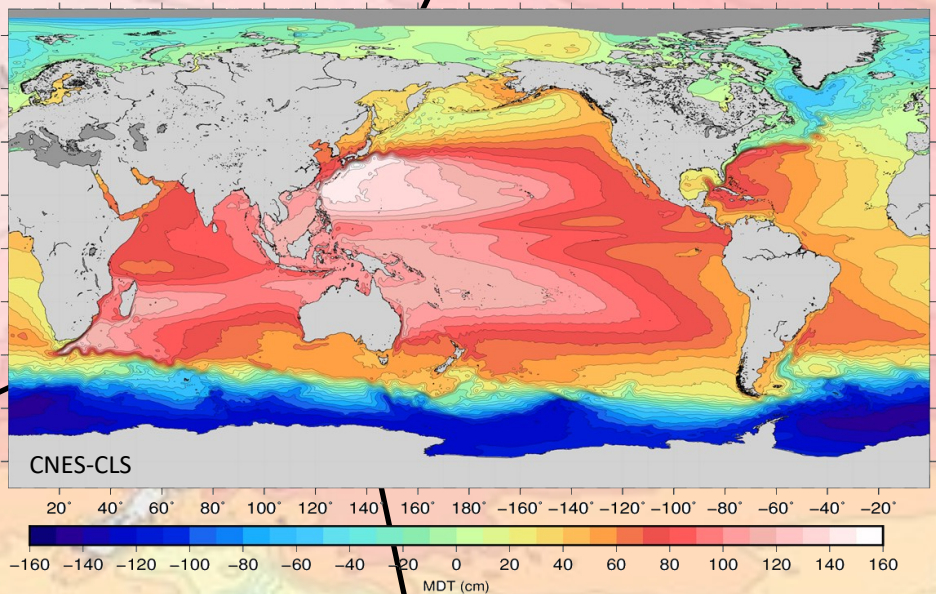
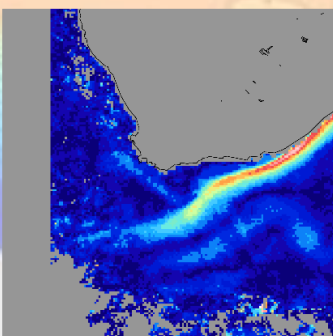
CNES-CLS13 MDT



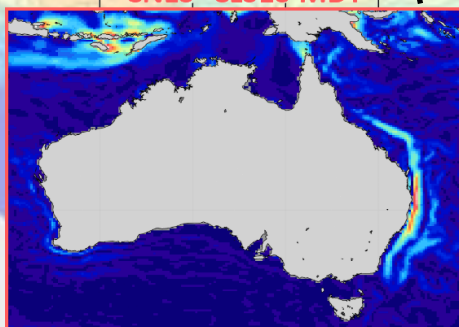
CNES-CLS18 MDT



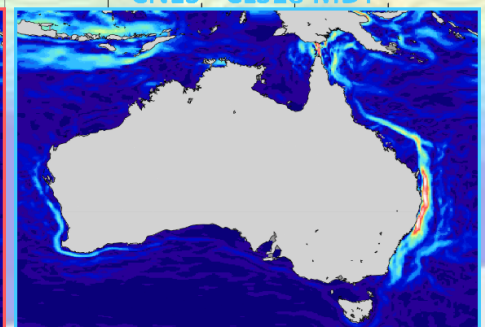
SAR mean velocities



CNES-CLS13 MDT



CNES-CLS18 MDT



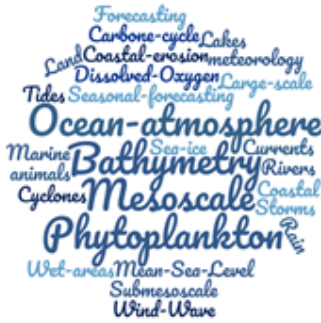
5 weeks. This is the time span of the survey, which was conducted online during April-May 2019.

294 people completed the survey



20 questions included, none of which were mandatory

User profiles and data use



The users have an **integrated** approach: several areas of interest, several data sources.



More than one out of two users expressed a need for data **in both** delayed-time (DT) and near real time (NRT).



A new secured access protocol

60% 60% found this change of protocol **complicated** and of these,

66% 66% admitted to needing **help in dealing with this change**

Interest in updates of existing products

87% were interested in the new **reprocessed** products (FSLE, Eddy Tracking, Climatologies).

~25% had already downloaded the latest update of one of these products and 6 out of 10 plan to do so.

85% were interested in future versions of the GDRs

~10% have even already planned to use this data to repeat the studies they had already made with the previous version of the GDR.

Website



50% did not know about the personal pages

ABC

12% of respondents found the font size of the texts to be very unattractive

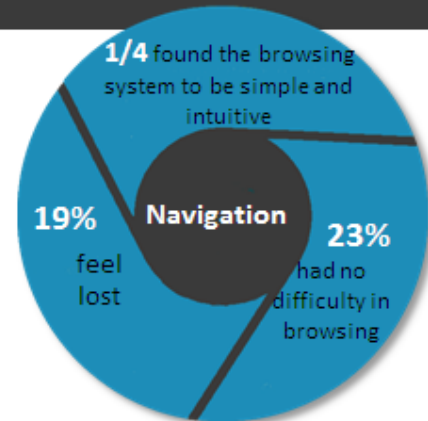


3 out of 4 users rated the **clarity** of the information from easy to very easy for the whole of the AVISO+ website.

As opposed to **1 out of 5** users that found it **difficult** to understand.

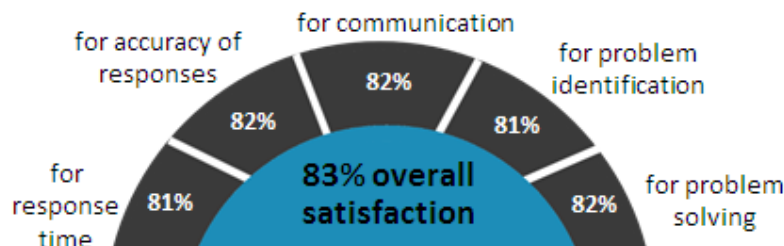


25% to 50% of the respondents visited the website **regularly**, from 2-3 times a week to once a month.



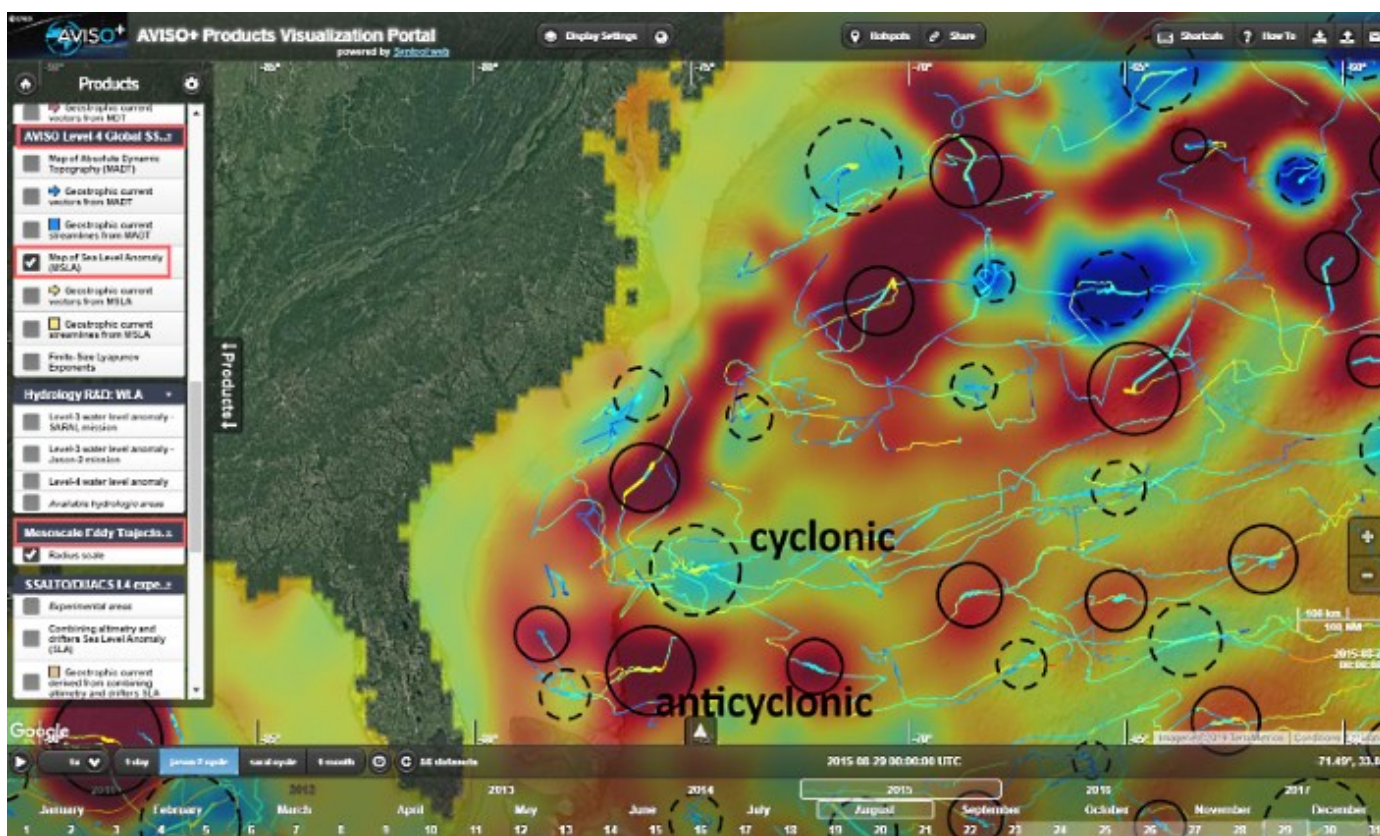
User helpdesk

Rate of satisfaction



C.Mercier, L.Soudarin, F.Mertz

New products on the Aviso'VIZ visualization portal



Aviso'VIZ screen capture showing Map of Sea Level Anomalies products (background colors) and Mesoscale Eddy Trajectories (continuous black circles for anticyclonic eddies and discontinuous for cyclonic eddies; their trajectory is plotted with the SLA amplitude). Credits OceanDataLab, CMEMS, CLS, LEGOS/CTOH, LOCEAN.

A new release of the Aviso'VIZ portal provides new capabilities and new products, recently disseminated through AVISO+ or CMEMS.

The **CNES Aviso'VIZ visualization portal** developed by [OceanDataLab](#) aims to promote altimetry-derived products and to help users discovering new products with interactive visualization.

The latest upgrade includes the following features : all SSALTO/DUACS L4 experimental products, additional missions for along-track (Cryosat-2, HY-2a), large time extensions to have common period on samples of each product, animation for mesoscale eddies trajectories (the timeline is a very good support for telling the eddies's life, see figure above), aes-

thetic changes on wind/waves (continental mask in particular) and several options to plot currents (streamlines or vectors)

Aviso'VIZ also enables to bookmark your configured views and share them. See online the screen capture above by clicking [here](#).

Events



- December 09-13, 2019**, San Fransisco, CA, USA, [AGU Fall Meeting](#)
- February 4-7, 2020**, Frascati, Italy, [12th Coastal Altimetry Workshop](#) (CAW)
- February 16-21, 2020**, San Diego, CA, USA, [Ocean Sciences Meeting 2020](#)
- April 20-23, 2020**, Taormina, Italy, [Cryosat 10th Anniversary Science Conference](#)
- May 3-8, 2020**, Vienna, Austria, [EGU General Assembly](#)
- October 12-16**, Venice, Italy, Oceans from Space Symposium, 5th edition
- October 19-23**, Venice, Italy, Ocean Surface Topography Team Meeting (OSTST)

AVISO+ Users Newsletter

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