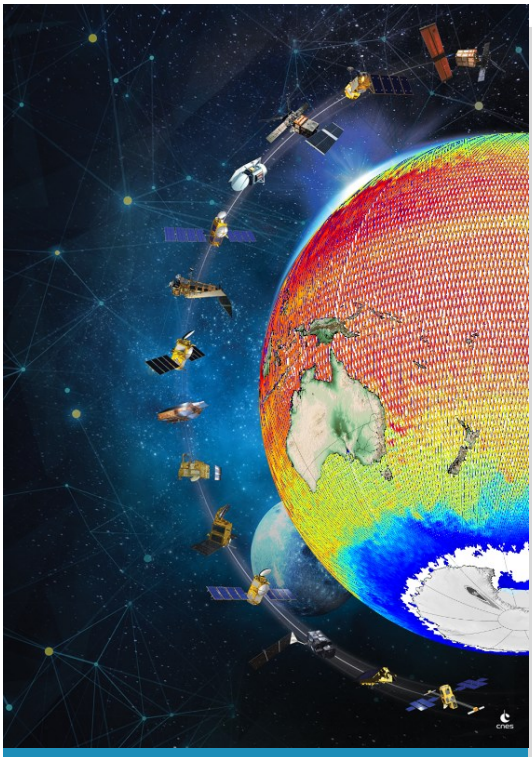
AVISO+
Satellite Altimetry Data

Users Newsletter

#15

September 2018



SUMMARY

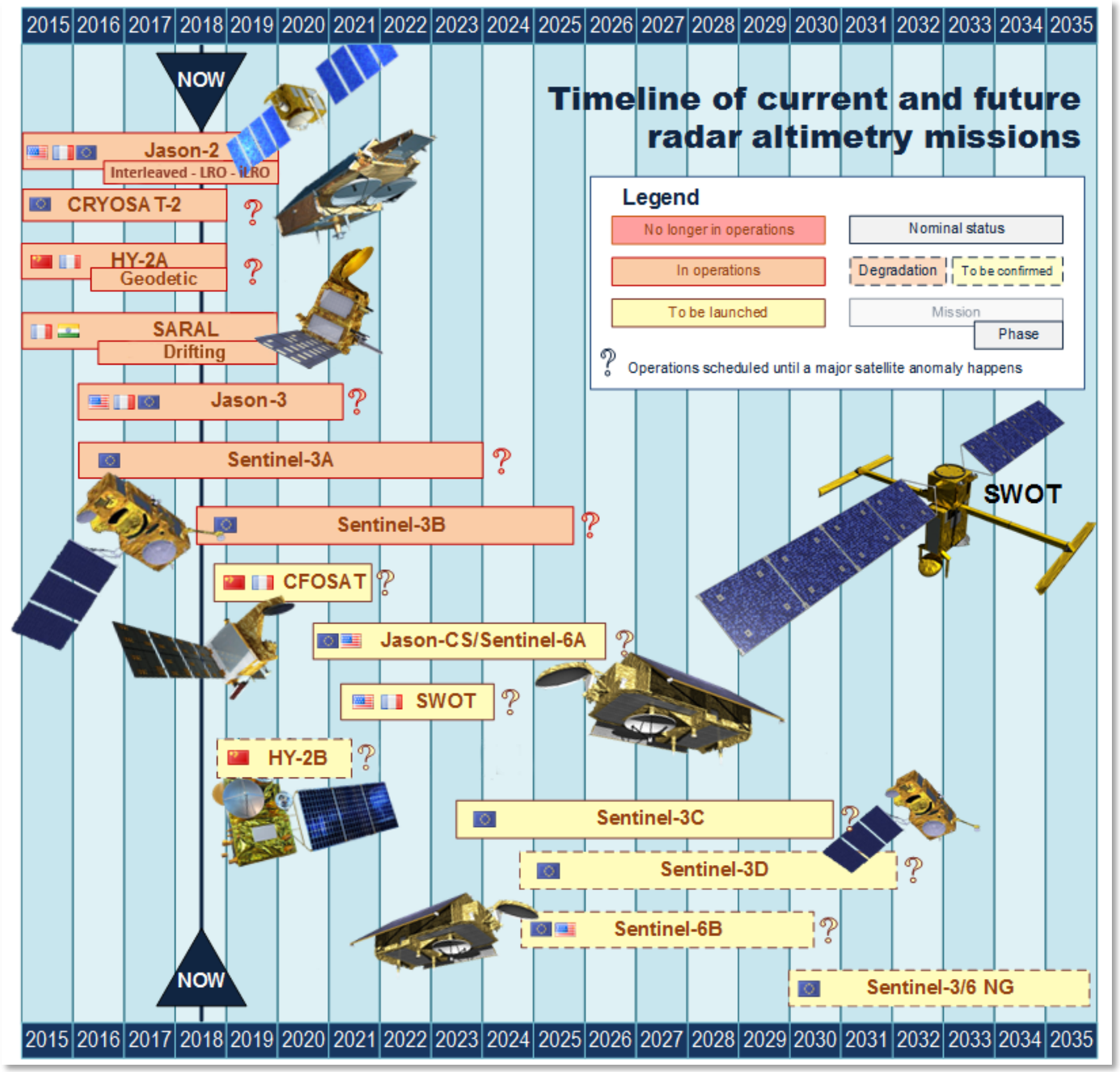
Project news

CNES, Nicolas Picot , Thierry Guinle and project managers

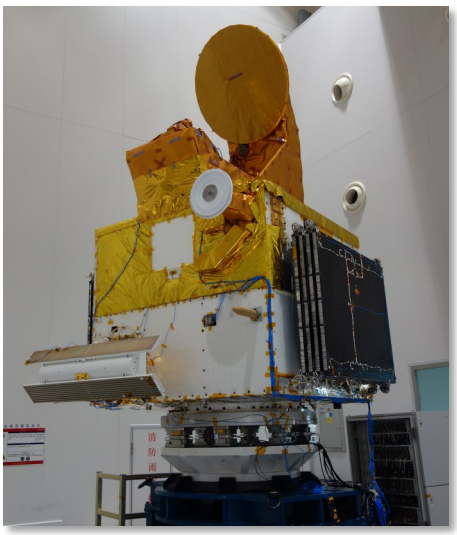
The virtual altimeter constellation currently still includes six operating satellites. Sentinel-3B is currently in commissioning phase. CFOSAT will be launched later this year.

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 on April 2018 with a Rockot launcher and is currently in its commissioning orbit. It is in tandem with its twin Sentinel-3A (30 seconds ahead, corresponding to ~223 km). The mid-term topography review was organized in the CNES premises on July 11-13, 2018 and showed that the satellite, instruments and ground processing are fully in line with mission requirements. The In-Orbit Commissioning Review will be held on October 16-17, 2018 at ESRIN. Products will be released widely after this review.

CFOSAT, the Chinese-French oceanography mission operated by CNES and CNSA, is devoted to ocean surface wind and wave observation. The satellite integration process is now in its last straight line and the launch is planned for October 29 this year. The data will be freely accessible after the commissioning phase (~6 months) for scientific purposes. The scientific opportunity call is on-going until September. If you want to join the Science Team and contribute to the commissioning phase and CAL/VAL, submit your proposal or contact Cédric Tourain at CNES to learn more.



Timeline of current and forthcoming radar altimetry missions. Credits CNES.



CFOSAT satellite which the launch is planned for October 29, 2018, Credits DFH Satellite Co., Ltd.

The **Jason-3** Satellite is performing nominally and is the reference mission for the AVISO+ and CMEMS DUACS system. After nearly 10 years in orbit, the CNES/NASA/EUMETSAT/NOAA OSTM/**Jason-2** mission continues to provide the altimetry community with high-quality products despite a few periods during which it is unavailable due to the ageing of some components. In July 2017, Jason-2 was placed on a Long Repetitive Orbit (LRO) at an altitude of roughly 1309.5 km. One year after (when the first geodetic cycle was completed), Jason-2 was again moved to reach an "interleaved LRO" (i-LRO) so that more precise results are available for geodetic purposes. With the i-LRO, the ground track is now in the middle of the grid defined by the LRO. Jason-2 coverage and products quality remains excellent and operational. Teams are doing their utmost to ensure the best possible data availability.

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. The mission is working without a hitch and has provided valuable Ka-band altimetry results for more than five years now. In the summer of 2016,

SARAL/ AltiKa was placed on a geodetic orbit. Main objectives of this move was to improve geodesy and create new data to enhance Mean Sea Surface (MSS) models. However, even on the drifting orbit, the performances of the payload allow use of SARAL data for a large range of applications. SARAL exploitation phase has been formally extended up to the end of 2019 and the 4th Exploitation Review is planned in November.

Hy-2A, launched in August 2011, is a Chinese mission 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 a geodetic orbit around 2 km higher. The new orbit has a 168-day cycle with 2,315 orbits in the full cycle.

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). Cryosat-2 is expected to continue up to February 2019 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 date, has been scheduled and will be available (Baseline C).

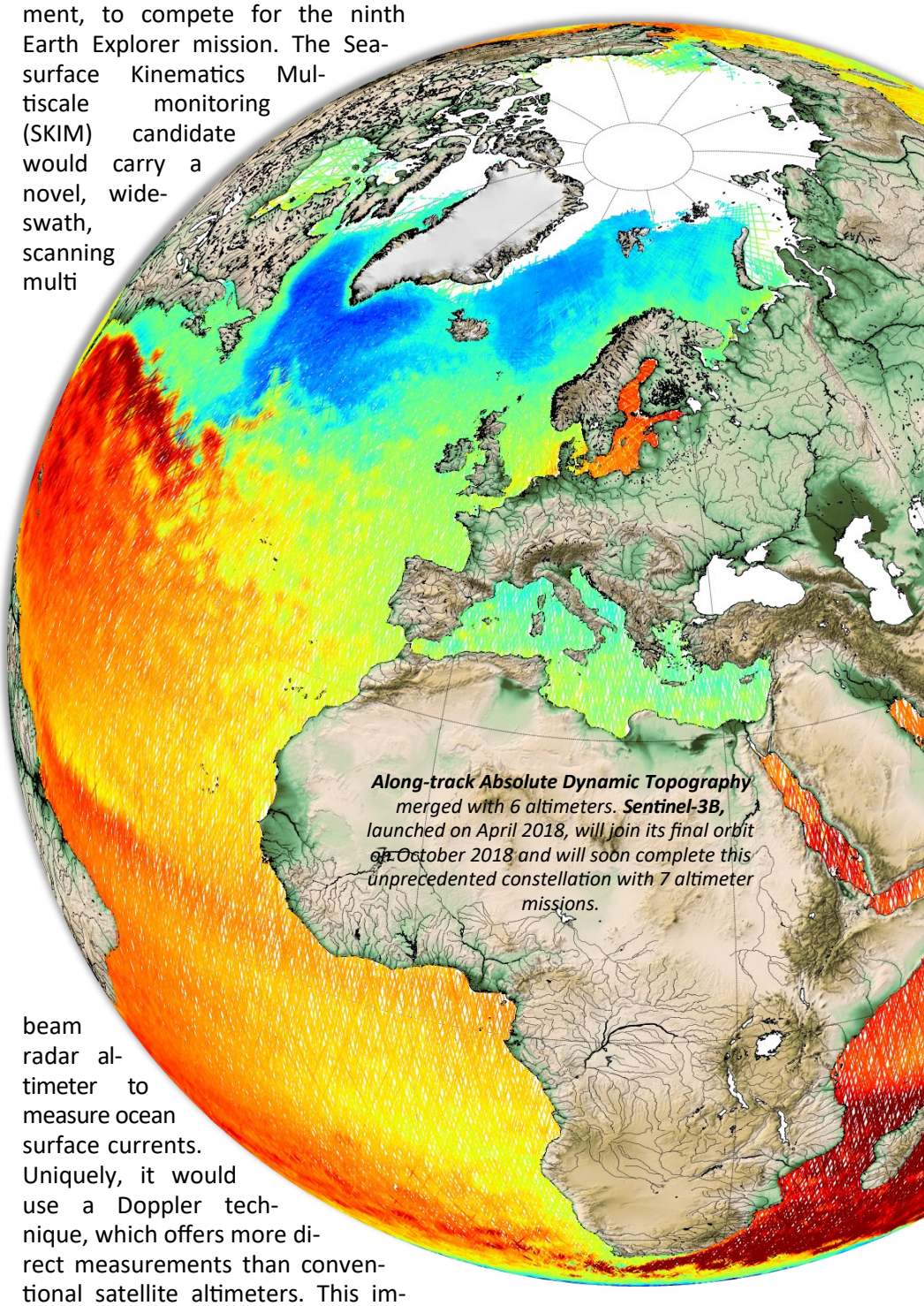
Four satellites are also in a geodetic and/or LRO orbit (Jason-2, SARAL, CryoSat-2 & HY-2A), thus providing a very dense coverage of the ocean surface as illustrated for the Florida region during the OSTST meeting in 2017 (see slide 9 on the OSTST presentation).

Ongoing developments

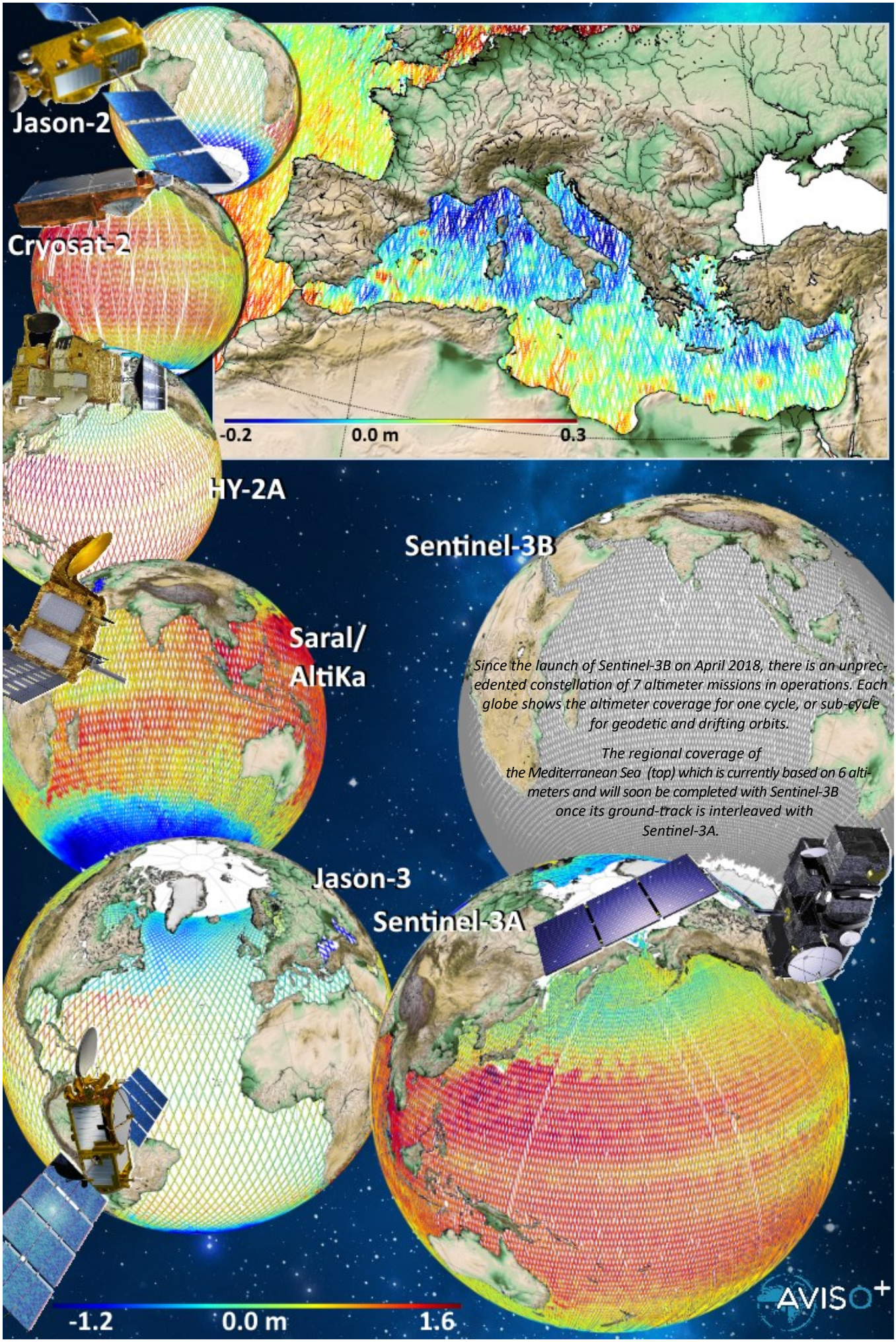
SWOT (Surface Water and Ocean Topography) is a French-American mission run jointly by CNES and NASA, with the participation of UKSA and CSA, to study oceanic and inland water surfaces. Mission progress is nominal, with the first deliveries of the CNES electric model to the JPL team. The mission's critical design review (CDR) was held successfully in May 2018. The platform development is ongoing, and almost all the equipment has been supplied. The first instrument flight models are expected to be delivered in early 2019.

ESA has chosen two concepts, **FORUM** and **SKIM** for further development, to compete for the ninth Earth Explorer mission. The Sea-surface Kinematics Multiscale monitoring (SKIM) candidate would carry a novel, wide-swath, scanning multi beam radar altimeter to measure ocean surface currents. Uniquely, it would use a Doppler technique, which offers more direct measurements than conventional satellite altimeters. This improve our understanding of vertical and horizontal ocean– surface dynamics over the global ocean every few days. This would increase our knowledge of how the ocean and atmosphere interact – for example, how atmospheric carbon dioxide is drawn down into the ocean.

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, late in 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.



Along-track Absolute Dynamic Topography *merged with 6 altimeters.* ***Sentinel-3B,*** *launched on April 2018, will join its final orbit in October 2018 and will soon complete this unprecedented constellation with 7 altimeter missions.*



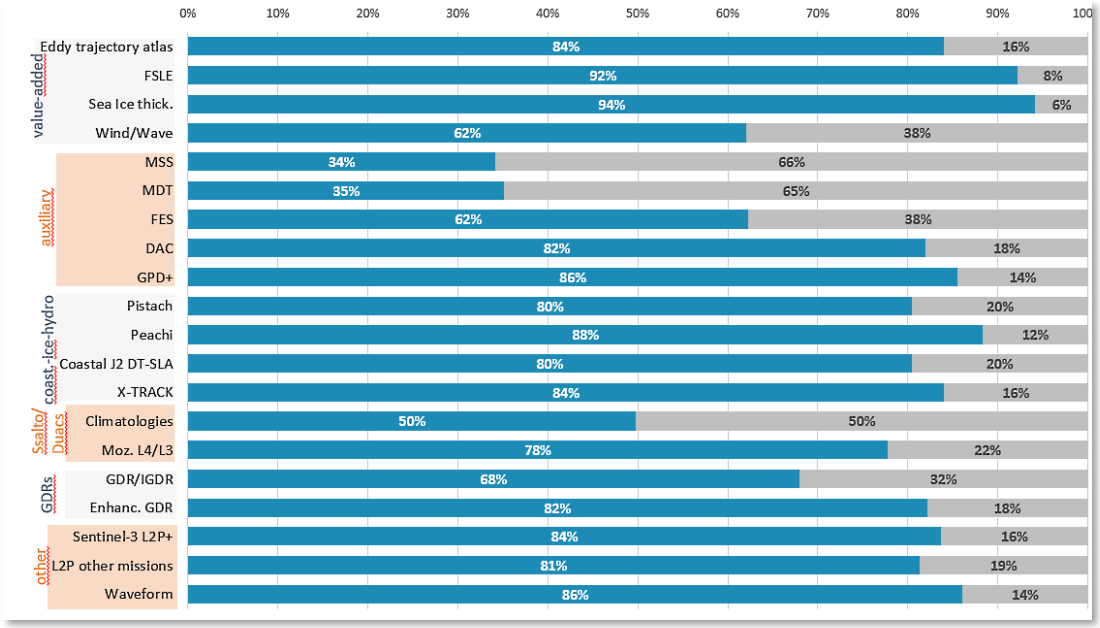
Since the launch of Sentinel-3B on April 2018, there is an unprecedented constellation of 7 altimeter missions in operations. Each globe shows the altimeter coverage for one cycle, or sub-cycle for geodetic and drifting orbits.

The regional coverage of the Mediterranean Sea (top) which is currently based on 6 altimeters and will soon be completed with Sentinel-3B once its ground-track is interleaved with Sentinel-3A.

Aviso+ User Satisfaction Survey: What are you telling us?

Caroline Mercier

Every year, a user satisfaction survey on our products, services and the website is sent to users. Your responses provide a useful and dynamic basis to help us understand how our products and services are used. Thanks to all the many users who took the time to complete this year's survey!



For each type of AVISO+ product whose name appears on the left, the proportion of users who do not know about or do not use it is shown in blue, and the proportion of users who use it is shown in grey.

Several topics raised in this survey are now among the recurring questions asked from year to year to help us track changes in user practice. This year again, some of our questions focused on the **notoriety of and the degree of difficulty in learning to use** our products.

Not surprisingly, the most frequently used products are the most traditional and elaborate (Level-4 Climatologies) as well as the oldest products: Mean Sea Surface (MSS) and Mean Dynamic Topography (MDT). On the other hand, the less used products are more recent introductions, whose applications are more specific or whose use requires a certain degree of technical and scientific expertise (FSLE, Atlas of mesoscale eddies, etc.).

The survey also found that between 2 and 4 out of 10 respondents who did not previously know about a type of product said they would be interested in using it.

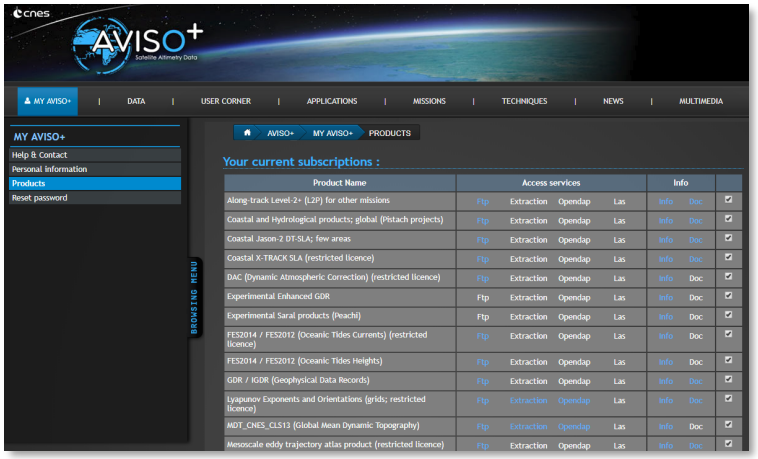
This wide variety of products offers a wealth of possibilities but is also a source of **difficulty** for users who have to find their way through this large selection and work out which product and which variables are most suitable for their particular studies.

Among the **aids and tools** we suggested in the survey for guiding users through the wide range of products, the most popular were the "literature references" (average score of 8.3/10) and also tutorials and examples of programs/scripts for manipulating data (score of 8.1/10). Users were slightly less interested in download tools, either for downloading data faster or according to a specific network the EUMETCast multicast system), or for manipulating/editing data before downloading (score from 7.5 to 7.8/10).

This year (March 2018), personal spaces were set up on the AVISO+ website to address some of these issues.

My AVISO+

"My AVISO+" is your new private space where you can find the list of the AVISO+ products you have subscribed to. From this reserved area, you can access your products as well as the related documentation available on the website. You can also check your personal information, reset your password, request other products (you no longer need to complete the registration form to ask for new products), or unsubscribe from a product.



Screenshot of a page from the "My AVISO+" personal space.

New generation of DUACS products with finer resolution

CLS, CNES, Yannice Faugere, Clément Ubelmann, Isabelle Pujol, Marie-Hélène Rio, Pierre Prandi, Antoine Delepoulle, Maxime Ballarotta, Elodie Charles, Sandrine Mulet, Michael Ablain, Pierre Thibaut, Ngan Tran, Patrick Leildé, Nicolas Picot, Gérald Dibarboure.

While the operational DUACS Sea Level Anomalies along-track and map products are now generated as part of the Copernicus Marine Environment Monitoring Service, last year CNES started to develop a new generation of DUACS products with finer resolution.

Toward the small-scales

First, a 20 Hz L2 altimetry infrastructure has been set up for all missions over the last few years. This database has been enhanced with a noise reduction algorithm (Zaron, 2016) and new editing techniques. Classic cross-calibration (Pujol, 2014) was then applied in order to obtain a homogeneous multimission L3 dataset, subsampled at 1 km resolution, ready to be assimilated in regional numerical models. Spectral analysis demonstrated the capability of high resolution (HR) products to better observe the small-scale signal over the European Seas up to nearly 30 km with AltiKa and Sentinel-3A and 45 km with Jason-2, whereas the classical 1 Hz product is limited to nearly 65 km (Dufau et *al.*, 2016). This will eventually benefit the regional ocean models through assimilation, and the first tests performed by Mercator Ocean are promising (Benkiran, 2018).

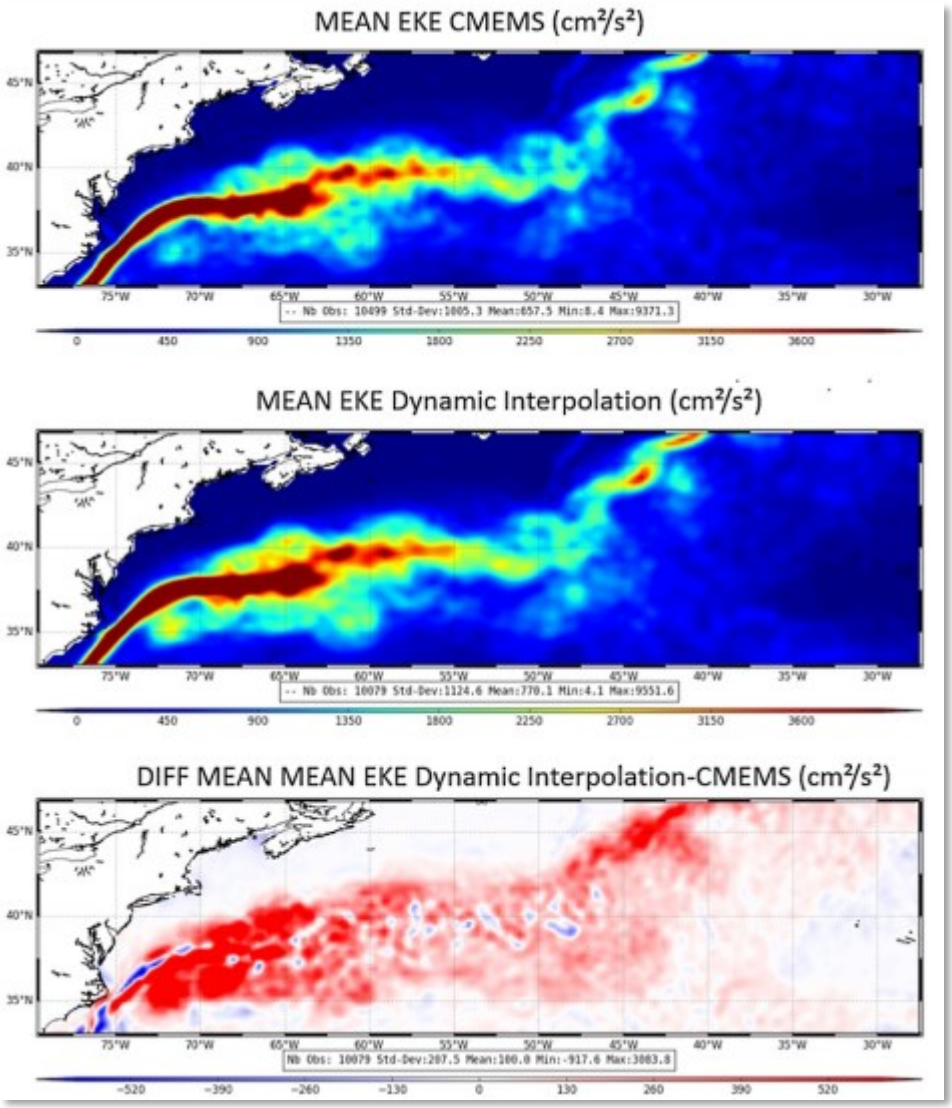


Figure 1. Comparison of mean Eddy Kinetic Energy (EKE) over the period [2014/04/12/04-2015/12/2015] for DUACS products: CMEMS (top), Dynamic Interpolation (middle) and the difference between the two (bottom), where red indicates areas of higher energy. See an animation here.

Innovative mapping techniques

Since then, we have been developing and testing several innovative mapping techniques within this project to take advantage of the dense observations now available, and to improve the restitution of non-linear dynamics. A dynamic interpolation method allowing propagation modeling of spatial covariance has been implemented and improved as part of this project. Tests have been performed in several regions and a series of validations and comparisons against independent data have been conducted to assess the performances with respect to the reference CMEMS gridded maps. More mesoscale activity is retrieved over the areas, and comparison (see Figure 1) with independent measurements shows considerable error reduction (20%) in the high-energy vein of the Gulf Stream area.

Merging

In parallel, in this project we have been investigating the benefits of merging different sources of observation (satellite and *in-situ*) to improve resolution. Sea Surface Temperature fields (from microwave and infra red sensors) have been

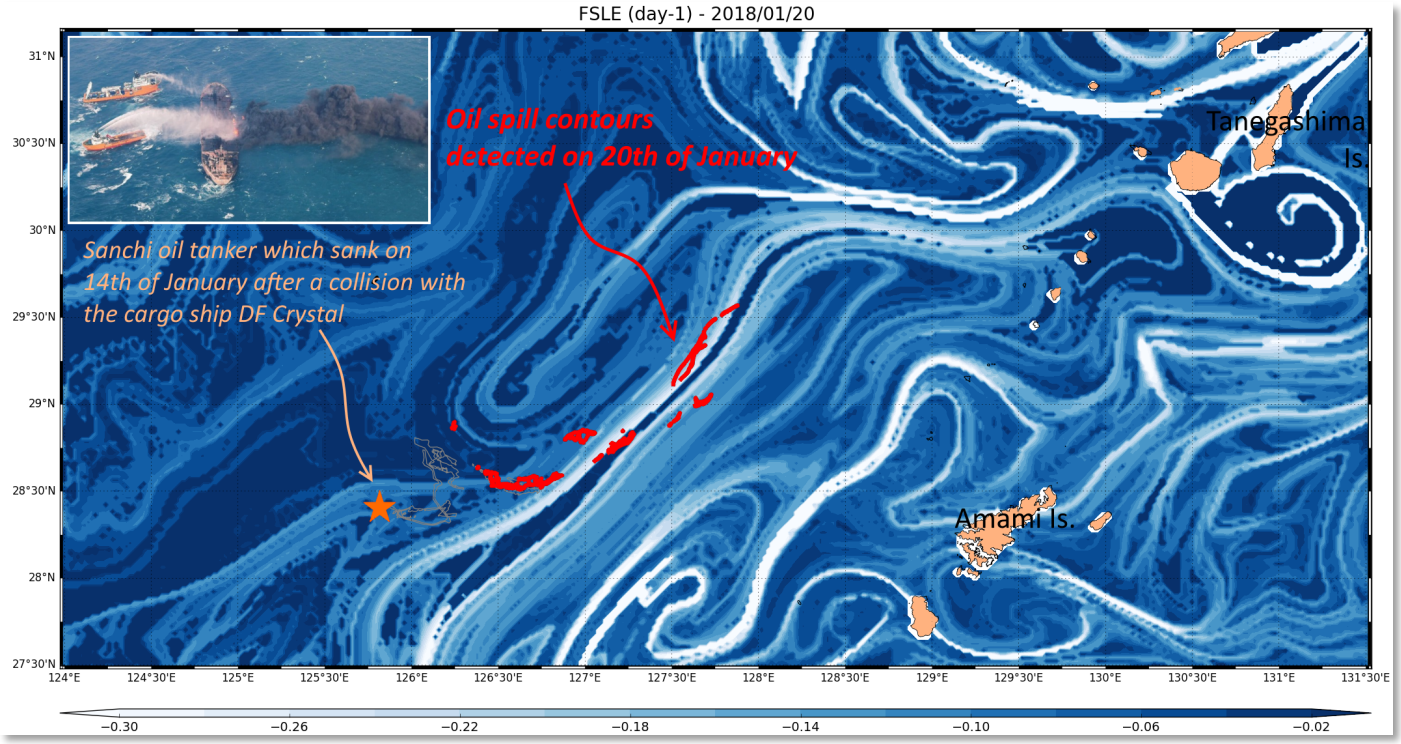


Figure 2. Oil spill in the China Sea resulting from the Sanchi oil tanker disaster (January 2018) superimposed over the FSLE products (unit day-1) for the same day. The oil spill contours were detected using satellite imagery in the visible range and SAR (data source Copernicus & Aviso, analysis performed by CLS). The FSLE used here were computed at 2 km resolution from optimized multimission altimetry maps. See an animation here.

used to complete the geostrophic currents derived from altimetry mapping following a new methodology (Rio et *al.*, 2018). Tests on the global ocean demonstrated the improvements on the velocities, notably for the meridional component in areas where SST gradients are greater than 10^{-5}°C/m. The combination of along-track Sea Level Anomalies with geostrophic velocity estimated from surface drifting buoys can also improve L4 products locally. Assessment of such combined maps in the Gulf of Mexico with independent data shows an improvement of geostrophic current estimates by 15% in the meridional direction (component less well resolved by nadir altimetry due to the North/South orientation of the tracks) (Mulet et *al.*, 2017).

Value-added products

Finally, the DUACS Sea Level maps are also used to derive value-added products such as an Eddy Trajectory Atlas, and Lagrangian products such as Finite Size Lyapunov Exponents (FSLE). FSLE provide the exponential rate of separation of particle trajectories initialized nearby and advected by altimetry velocities. An application of this product is illustrated in Figure 2, where the oil spills detected after the wreck of the Sanchi tanker are superimposed over FSLE fields. As expected, the path and shape of this oil spill are found to be consistent with the position of the strong stretching areas underlined by FSLE values far from zero.

Further information

- Samples of all these new DUACS products are available on the Aviso+ web page.
- Animation with comparison of Eddy Kinetic Energy between DUACS operational and experimental
- Animation with the oil spills of the Sanchi oil tanker detected from satellite imagery superimposed over the FSLE fields.

References

- All literatures references are linked on the AVISO+ web page.

Events

24-29 Sep. 2018: 25 Years of Progress in Radar Altimetry Symposium including the annual meeting of the OSTST and the IDS workshop, Saõ Miguel Island, Azores.

10-14 Dec. 2018: AGU Fall meeting, Washington DC, USA.

13-17 May 2019: Living Planet Symposium, Milan, Italy.

AVISO+ Users Newsletter

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