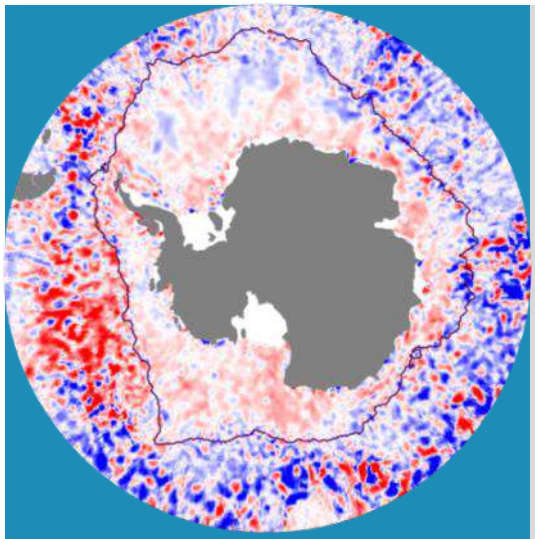
AVISO+ Satellite Altimetry Data

Users Newsletter

#19

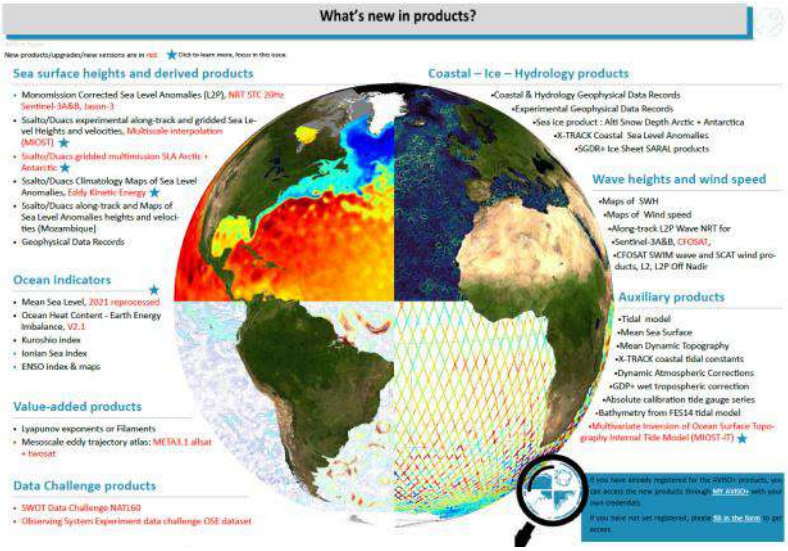
January 2022



SUMMARY

In this issue, discover all the AVISO+ products news: new versions for easier to use products, integration of new missions in some existing products, temporal extension, new algorithms, ... for an increased quality of AVISO+ services.

These products are ready to serve you by gathering the most appropriate dissemination services and supports that suit you: user manual, scientific publication, source code, ... and the AVISO+ user helpdesk. Feel free to contact the AVISO helpdesk to give your feedback or ask for questions.



A full double page on pages 2 and 3, with a mosaic of pictures "**What's new in products**" recalls all these new products and version upgrades. Internal links are directly inserted to redirect you to the detailed article corresponding to a given product, in this newsletter. Other external links redirect you to the product pages of the AVISO+ website.

We hope you enjoy this new issue; we also wish you a **fruitful and healthy 2022 year with** many opportunities to use AVISO+ products!

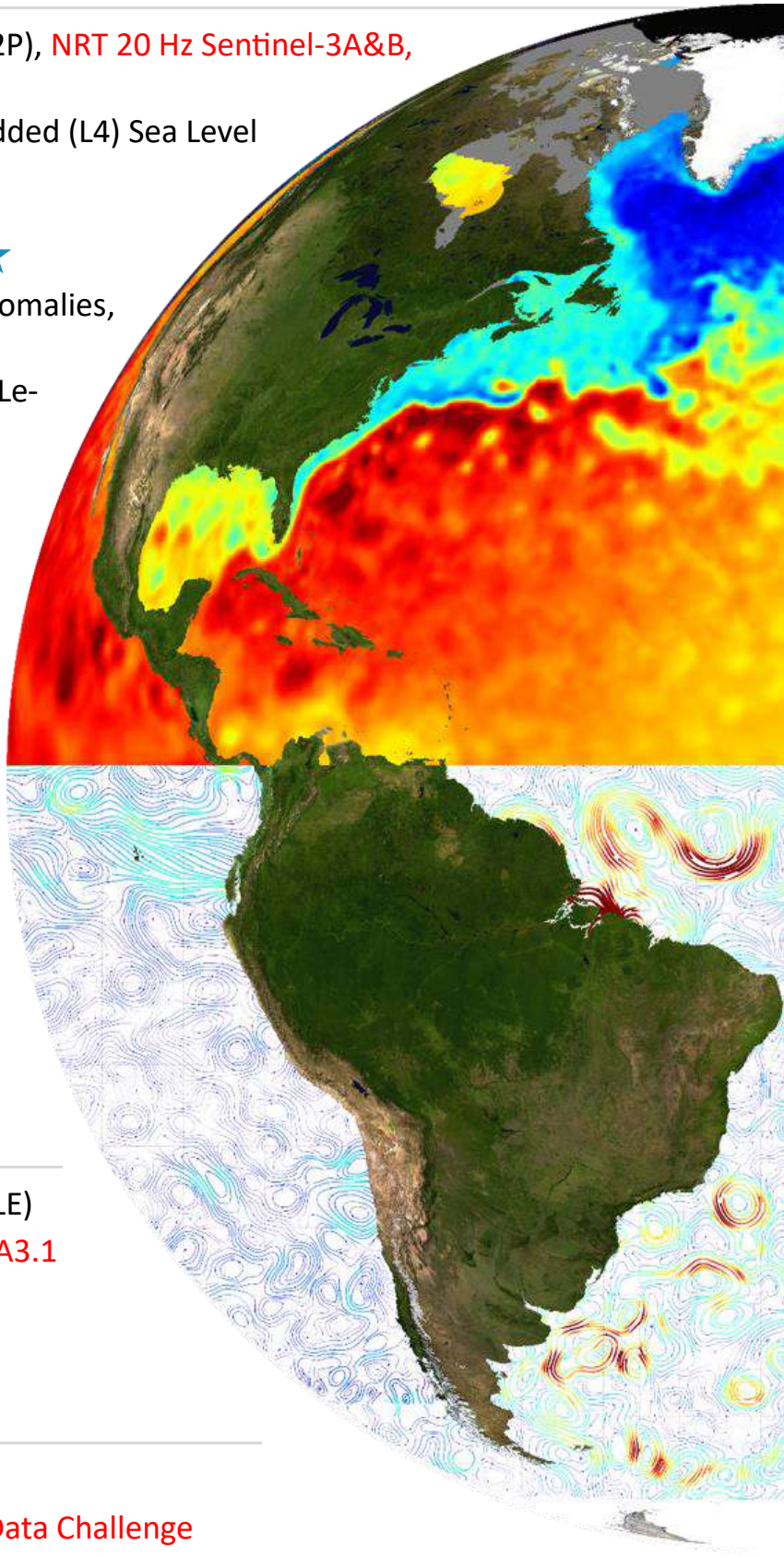
What's new in products? (1/2)

AVISO+ Team

New products/upgrades/new versions are in red. ★ Click to learn more, focus in this issue.

Sea surface heights and derived products

- Monomission Sea Level Anomalies (L2P), NRT 20 Hz Sentinel-3A&B, Jason-3
- Experimental along-track (L3) and gridded (L4) Sea Level Heights and velocities, Multiscale interpolation (MIOST) ★
- Multimission SLA Arctic + Antarctic ★
- Climatology gridded (L4) Sea Level Anomalies, Eddy Kinetic Energy ★
- Along-track (L3) and gridded (L4) Sea Level Anomalies heights and velocities (Mozambique)
- Geophysical Data Records (L2) (GDRs)



Ocean indicators ★

- Mean Sea Level, 2021 reprocessed
- Ocean Heat Content - Earth Energy Imbalance, V2.1 ★
- Kuroshio index
- Ionian Sea index
- ENSO index & maps

Value-added products

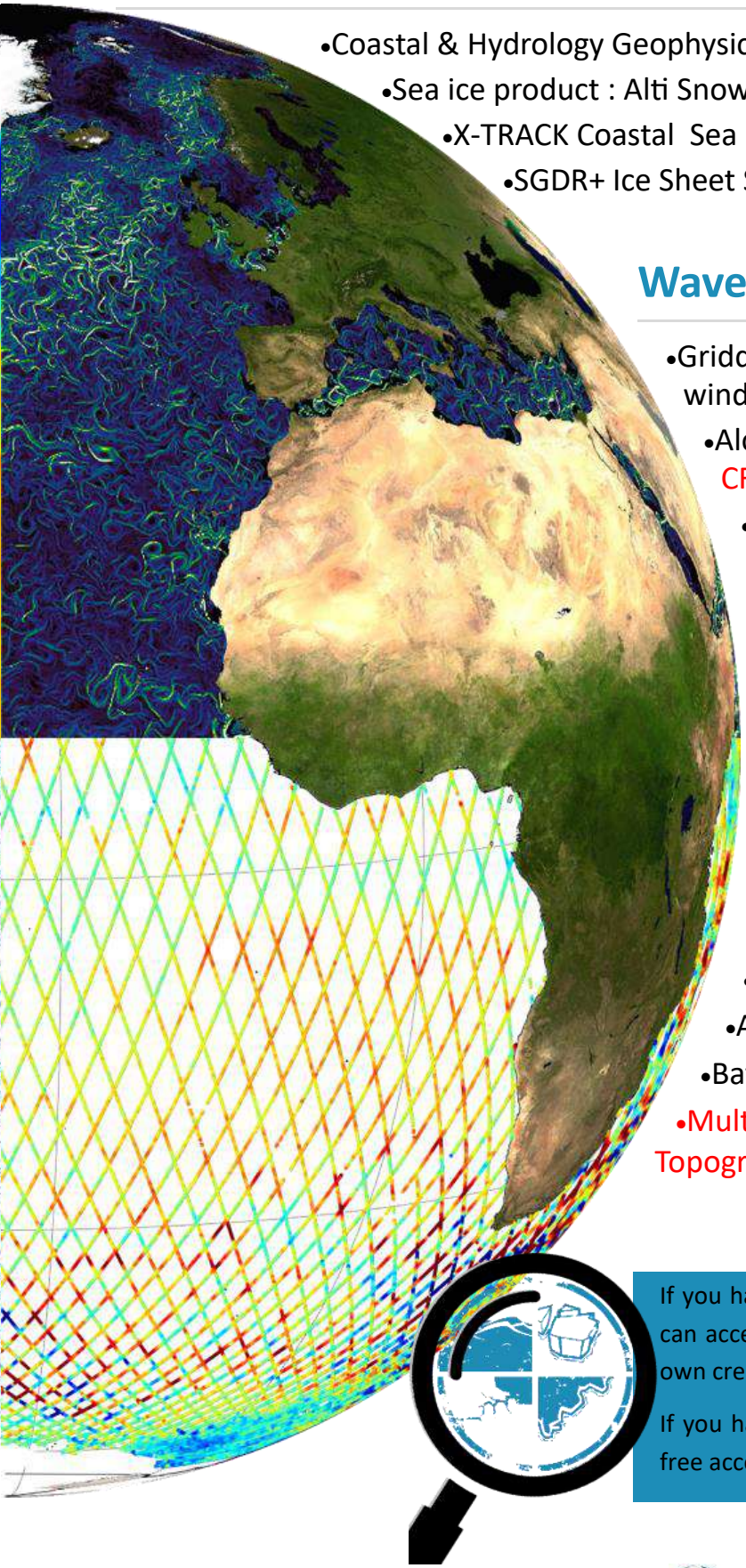
- Lyapunov exponents or Filaments (FSLE)
- Mesoscale eddy trajectory atlas: META3.1 allsat + twosat ★

Data Challenge products

- SWOT Data Challenge NATL60
- Observing System Experiment (OSE) Data Challenge

What's new in products? (2/2)

Coastal – Ice – Hydrology products



- Coastal & Hydrology Geophysical Data Records
- Sea ice product : Alti Snow Depth Arctic + Antarctica
- X-TRACK Coastal Sea Level Anomalies
- SGDR+ Ice Sheet SARAL products

Wave heights and wind speed

- Gridded (L4) Significant Wave Height and wind speed
- Along-track (L2P) Wave NRT Sentinel-3A&B, CFOSAT
- CFOSAT SWIM wave and SCAT wind products (L2, L2P) Off Nadir ★

Auxiliary products

- Tidal model
- Mean Sea Surface
- Mean Dynamic Topography
- X-TRACK coastal tidal constants
- Dynamic Atmospheric Correction
- GDP+ wet tropospheric correction
- Absolute calibration tide gauge series
- Bathymetry from FES14 tidal model
- Multivariate Inversion of Ocean Surface Topography Internal Tide Model (MIOST-IT) ★

If you have already registered for the AVISO+ products, you can access the new products through MY AVISO+ with your own credentials.

If you have not yet registered, please fill in the form to get free access.

L2P OFF nadir CFOSAT product
Easy-to-use spectral product

Annabelle Ollivier, Romain Husson, Charles Pereux, Cedric Tourain, Gerald Dibarboure, Jean Michel Lachiver, Lotfi Aaouf, Daniele Hauser.

A new CFOSAT Off Nadir Level-2+ (L2P) WAVE product is available: Give it a try!

Since mid-March 2021, the 2nd CFOSAT International Science Team Meeting has considered that the mission data are mature and thus suitable for scientific usage and applications.

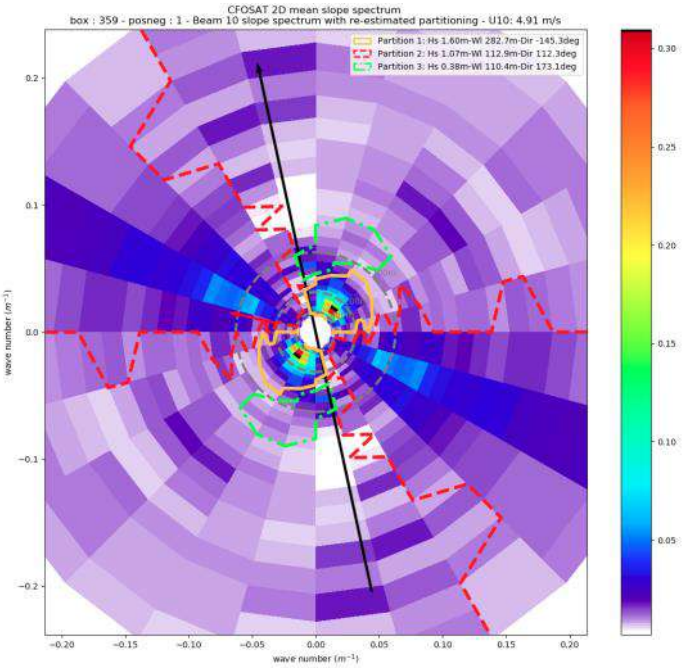
With more than 25 publications already available, the potential of this innovative mission is now being revealed.

Designed for users who are unfamiliar with the mission, the added-value L2P products are dedicated to all users of the community who want to have easy access to innovative CFOSAT data. While the L2 products themselves contain numerous variables, the L2P data files are simpler, less technical, products which contain only essential variables and simplified flags.

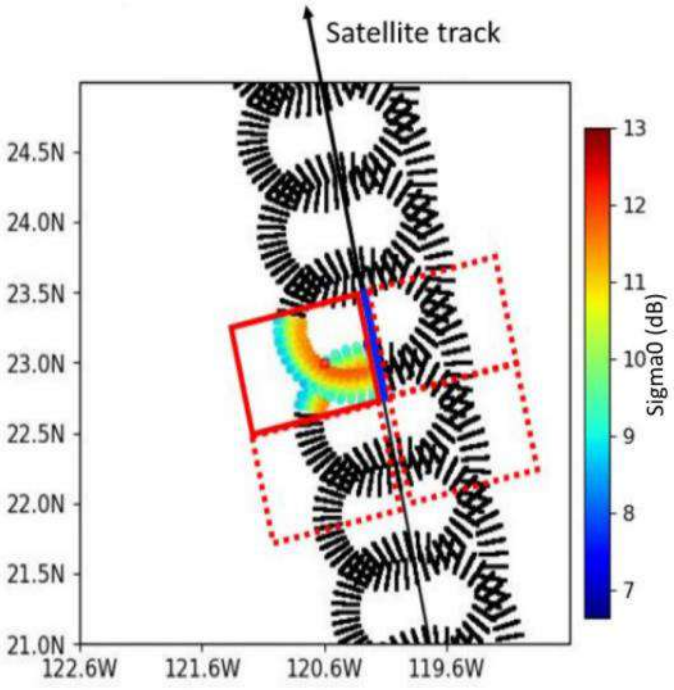
In synergy with the needs of the WAVE-TAC (Thematic Assembly Centre), one of the eight TACs of the Copernicus Marine Environment and Monitoring Service (CMEMS), SWIM L2P products will also be the source of L3 'firework' products soon to be available in the CMEMS catalogue, with a format comparable to Sentinel -1 products.

The product is processed by CNES/CLS, in Near-Real Time (3h). It has been available since 2019/04/25, the date of the onboard processing chain upgrade made to correct the spectral beams, before which, no reliable wave spectra were available.

Product sheet Description of the product, handbook and access, can be found **here**.



CFOSAT 2D Slope spectrum for one 70/90 boxe and its 3 partitions. The color is the spectral energy, related to the Hs, the distance to the center is related to the Wave Period and the Direction is given in a North/South meteorological convention. Credits CNES/CLS.



Example of a SWIM Off-Nadir box (red solid box 90 km wide/70 km long) to the left of the satellite track, together with the associated nadir « box » (blue line along the track). Credits CNES/CLS.

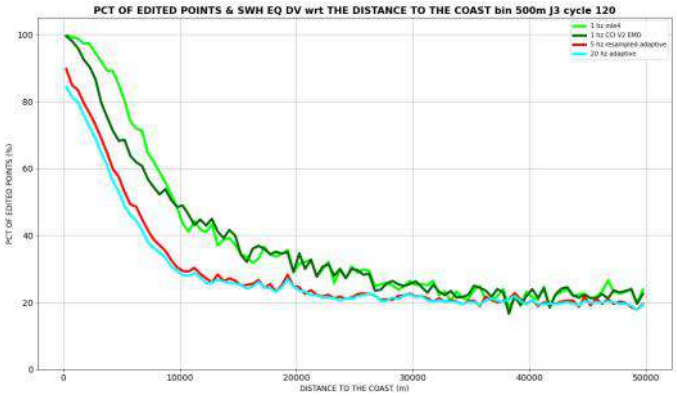
A new generation of 5Hz L2P wave product

Annabelle Ollivier, Adrien Nigou, Gerald Dibarboure, Alice Dalphinet, Cedric Tourain, Victor Quet, Isabelle Pujol.

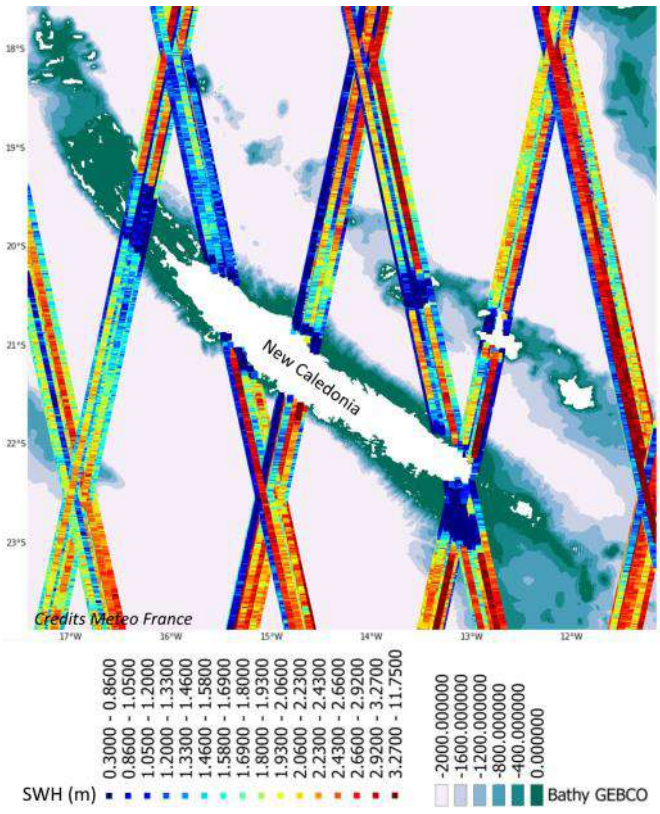
A new operational **Along-track Level-2+ (L2P) Significant Wave Height (SWH)** product is available:

- with a kilometric resolution it is 7 times more precise than that of 1Hz products and,
- no noisier than at 1Hz (thanks to dedicated pre-processing),
- with a tuned validation flag allowing up to 20% more valid data than at 1Hz less than 50km from the coast,
- smoother and with the same data gain near the coast than 20Hz data up to 1km from the shore.

This product starts with **CFOSAT** data, in addition to the 1Hz nadir L2P products, currently used in the CMEMS operational data flow. Jason-3 and Sentinel-3 data will follow soon.

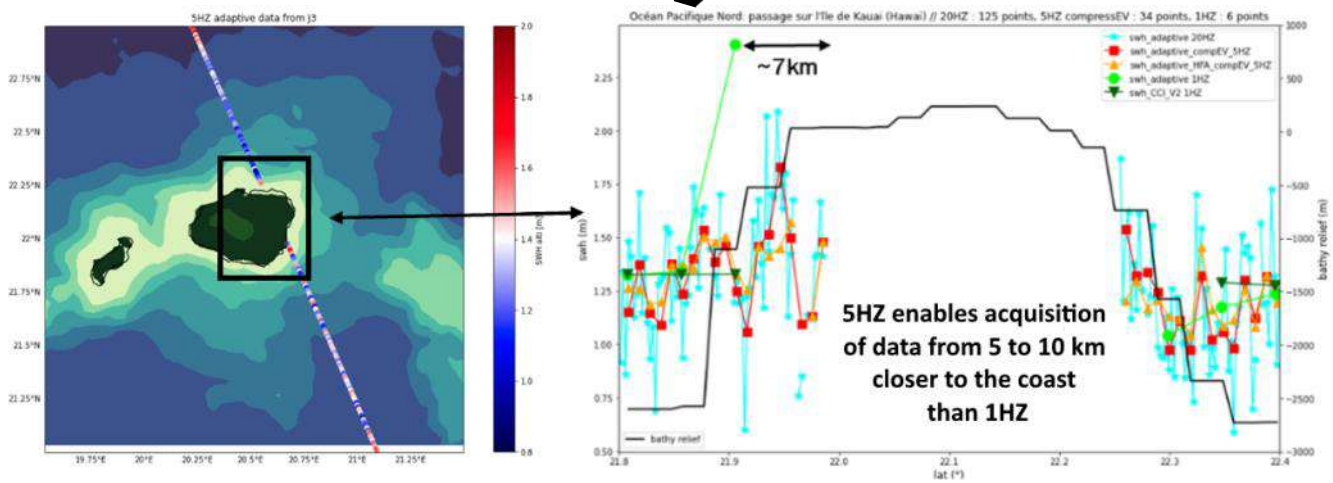


(above) Percentage of missing and/or invalid data per stretch of 500m when approaching coast, at less than 50km. Credits CNES/CLS.



(above) Significant Wave Height SWIM nadir 5Hz native (m) from January to June 2021. The superposition of the tracks during 6 months shows the good correlation between native data and bathymetry. The waves are broken at the passage of the barrier reef (30 m depth on average in the lagoon). Credits Meteo France, courtesy Alice Dalphinet.

Access to the **Product sheet**.



Signature of SWH processed at different sampling near coast in an atoll landscape context. 20Hz data is very noisy, whereas 5Hz data is fine and gets closer to the shore. Credits CNES/CLS.

New versions of the Mesoscale Eddy Trajectories Atlas product

Cori Pegliasco, CLS

The new versions of the Mesoscale Eddy Trajectories Atlas, **META3.1exp DT "allsat" and "twosat"**, provide new parameters for eddy detection and an improved tracking scheme.

The META3.1exp DT "**allsat**" (DOI : 10.24400/527896/a01-2021.001) and "**twosat**" (DOI : 10.24400/527896/a01-2021.002) versions differ from the historical META2.0 product with 4 major changes:

1. The **eddy detection is done on Absolute Dynamic Topography maps** instead of Sea Level Anomaly maps, for a better representation of Mean Dynamic Topography specific mesoscale structure patterns.
2. The **filter applied** on the input maps is a 2D Lanczos filter with a 700 km half-power cut-off wavelength, to better take into account the spatial scales of the Mean Dynamic Topography. The filter used in META2.0 had a 1,000 km half-power cut-off wavelength.

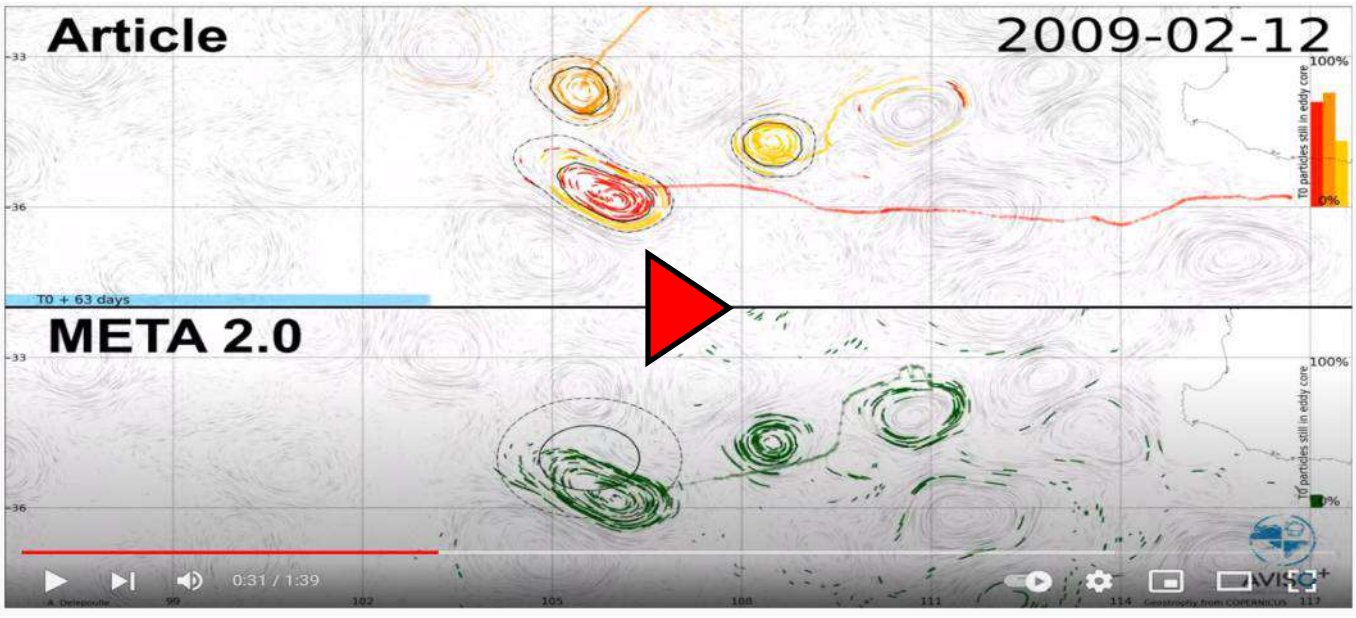
3. The **detection algorithm** of META3.1exp is the Py-Eddy-Tracker, freely available with a GNU license (here), written in the Python language and accompanied with a lot of documentation. The main changes are the amplitude threshold (0.4 cm), the unique extremum within an eddy, and the availability of the eddy's contours.
4. The **tracking scheme** is now based on the contour's overlap, with a maximum of 4 consecutive virtual eddies.

Each change was evaluated with a similarity coefficient, by comparing individual eddies in intermediate datasets, to ensure a continuity between META2.0 and META3.1exp.

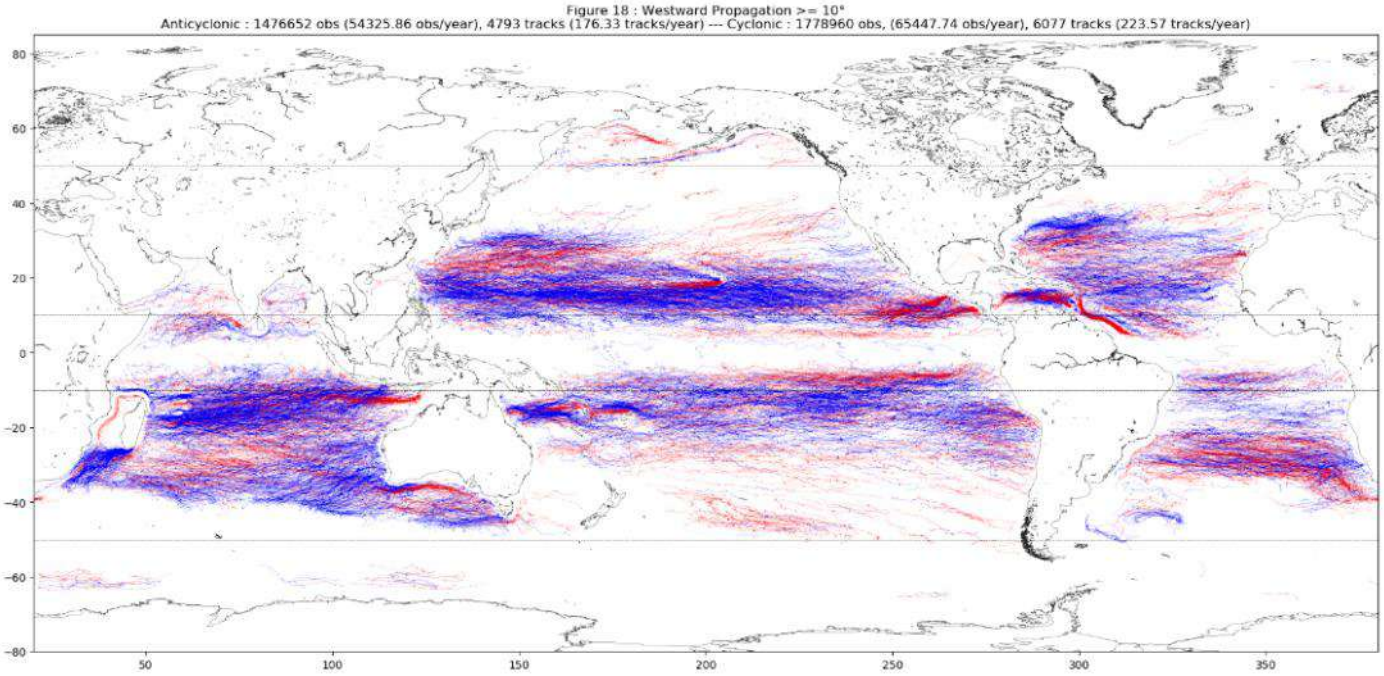
Product sheet Characteristics of each version, handbook, reading software, code delivery, citation, example, references, … can be found **here**.

Access AVISO+ users will find these products by selecting the "Mesoscale eddy trajectory atlas product » in "**My AVISO+**". If you are not yet a user, please complete the registration form.

Feel free to give your feedback on aviso@altimetry.fr



Comparison of detection algorithms for the Mesoscale Eddy Trajectories Atlas 2.0 and 3.1exp versions. Watch the full animation. Credits AVISO+.



Trajectories of all of the cyclonic (blue lines) and anticyclonic (red lines) eddies with lifetimes >= 16 weeks and propagating ***westward*** *a minimum of 10° of longitude. Credits CNES/CLS.*

(Right) Key figures computed on this new version Mesoscale Eddy Trajectories Atlas, ***META3.1exp DT "allsat".***
Max. lifespan, max. radius and max. speed correspond to ***Anticyclonic eddies*** *(AEs).*

Max. amplitude corresponds to ***Cyclonic eddies*** *(CEs). The other figures correspond to both types.*

Total individual eddies: 35 million AEs, 36 million CEs

Total trajectories: 1.2 million AEs, 1.2 million CEs

Trajectories lasting at least 10 days = ~60% of the trajectories but 92% of the individual observations

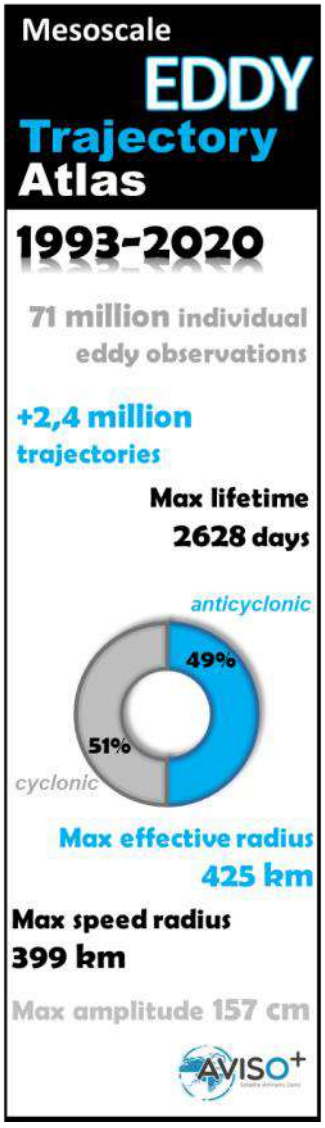
Ratio AEs - CEs: 49% - 51%

Max. amplitude = 156.7 cm

Max. radius: 399 km for speed radius, 425 km for effective radius

(speed radius = radius of the best fit circle with the contour of the maximum circum-averaged speed). See the same figure for the previous version in the 14th AVISO+ Users Newsletter, corresponding to the META2.0 version and for which only the 28-day trajectories were taken into account.

Credits AVISO+.



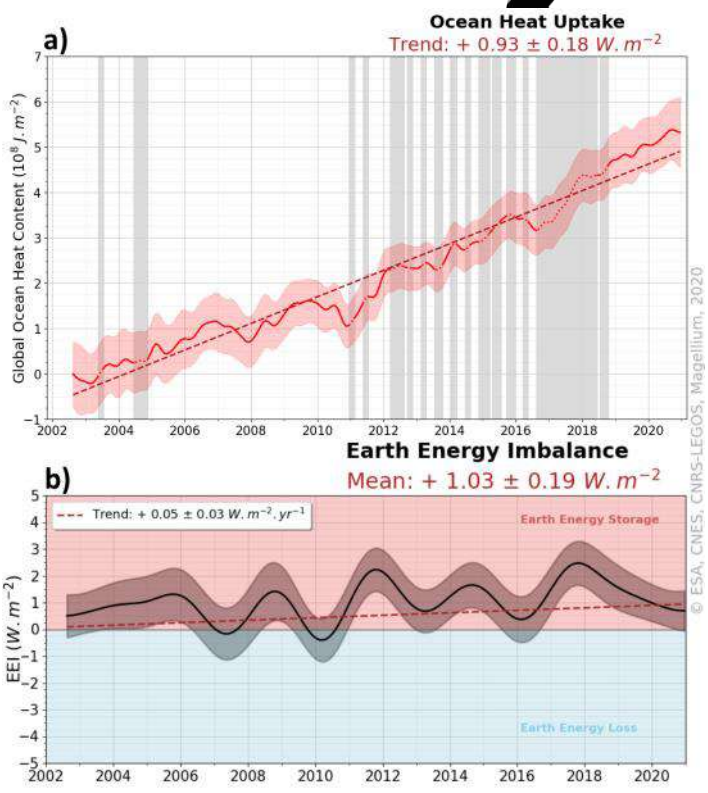
New release for the climate indicators from space: Ocean heat content and Earth energy imbalance

Florence Marti, Magellium

New release and scientific publication for the climate indicators from space: Ocean heat content and Earth energy imbalance.

The MOHeaCAN (*Monitoring Ocean Heat Content and Earth Energy ImbalANce from Space*) product developed by Magellium/LEGOS and supported by CNES and ESA has been released in a new version v3.

This product relies on the combination of altimetry and gravimetry observations to provide an estimate of the global ocean heat content and Earth energy imbalance (GOHC and EEI). Major updates have been made since the product version 1.0 (link to previous newsletter) including the application of an improved gravimetric dataset developed by the LEGOS (updated from Blazquez et *al.*, 2018) and an elastic correction on sea level data for recent melting. The new version (V3) fills the gap from August 2016 to June 2018 in ocean mass data thanks to an updated gravimetric dataset (including earthquake correction). The use of the latest Copernicus Climate Change (C3S) altimetry dataset (vDT2021) also allowed to extend the time series until December 2020. The positive trend on the GOHC from August 2002 to December 2020 is now estimated to 0.93 +/- 0.18 W/m² with a 90 % confidence level and confirms once again that on average the Earth stores energy. The ocean absorbs about 90 % of the excess energy stored by the Earth system, hence in the version 3 the ocean heat uptake is adjusted to account for energy contributions from other climate reservoirs (land, atmosphere, cryosphere) and results in a mean value of the EEI is 1.03 +/- 0.19 W/m² with a 90 % confidence level.



Times series of (a) global ocean heat content (GOHC) change and (b) Earth energy imbalance (EEI) from space geodetic approach (MOHeaCAN v3) over the August 2002-December 2020 period. Credits ESA, CNES, LEGOS, Magellium 2020.

Product sheet Characteristics of each version, product user manual, algorithm theorical basis document, citation, references, … can be found **here**.

The physical approach and the processing chain with the uncertainty propagation method have been described recently in a peer review paper (Marti et *al.*, 2021). This publication based on the version V2.1 of the product (August 2002 - June 2016) shows agreement in the various estimates of GOHC and EEI from *in situ* measurements (Argo network) and space observations by CERES (Clouds and the Earth's Radiant Energy System) instruments within the uncertainty levels. It also shows areas for improvement, such as a better combination of altimetry and gravity data or a more complete description of uncertainties.

Next steps

The MOHeaCAN product is planned to be improved in the months to come. In particular, information of the expansion efficiency of heat required to convert thermal sea level change into ocean heat content change will be further investigated.

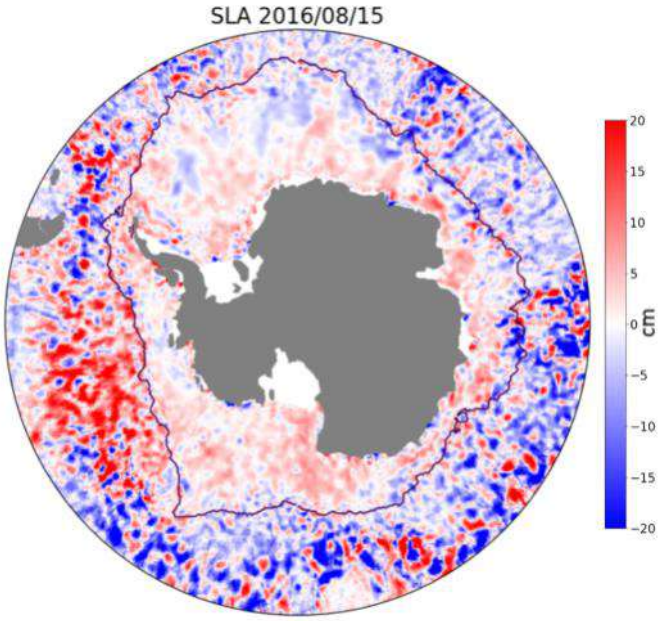
Gridded multi-mission SLA product for Antarctic Ocean

AVISO+ Team

Experimental Ssalto/Duacs gridded multi-mission altimeter products dedicated to **Antarctic Ocean** from April 2013 to July 2019. Sea level and geostrophic current anomaly grids.

Three satellites: SARAL/AltiKa, Cryosat-2 and Sentinel-3A.

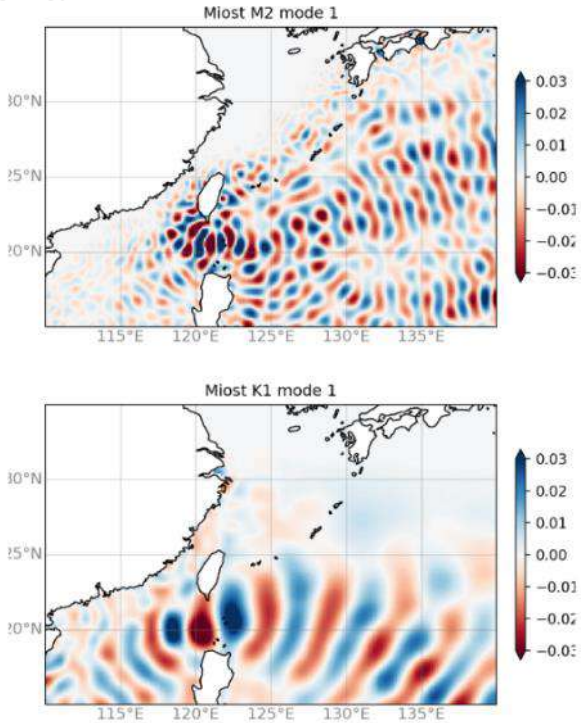
Multi-mission grid for Aug 15, 2016 of Sea level Anomalies (cm) for Antarctic Ocean. The black line is the sea ice contouring of 3% sea ice concentration. Credits CNES/CLS.



Product sheet Characteristics, citation, references, … can be found **here**.

Multivariate Inversion of Ocean Surface Topography Internal Tide Model (MIOST-IT)

AVISO+ Team



Reconstructed internal tide solutions in the Philippine Sea for M2 (top) and K1 frequencies, first mode contribution. Figure from Ubelmann C. et al. (2021), doi : 10.5194/os-2021-80. Credits CLS/OCEAN-NEXT/CNES/LEGOS.

The signature of internal tides has become an important component for high-resolution altimetry over the oceans. The MIOST-IT database includes 4 tidal components for the ocean internal-tide surface elevations. Each tidal component is described by 2 grids (amplitude and phase) plotted on a cartesian grid 1/10°x1/10°.

The internal tide elevations for the four tidal frequencies M2, S2, K1, O1, can be downloaded.

The tidal prediction code can also be downloaded in a "prediction" folder.

The MIOST-IT solution is based on an original gridding process using ocean signal variability modes and all altimeter measurements available for the nearly entire altimeter chronology.

Product sheet Characteristics, handbook, source code, citation, references, … can be found **here**.

Updated Mean Sea Level (MSL) Ocean Indicator products

AVISO+ Team

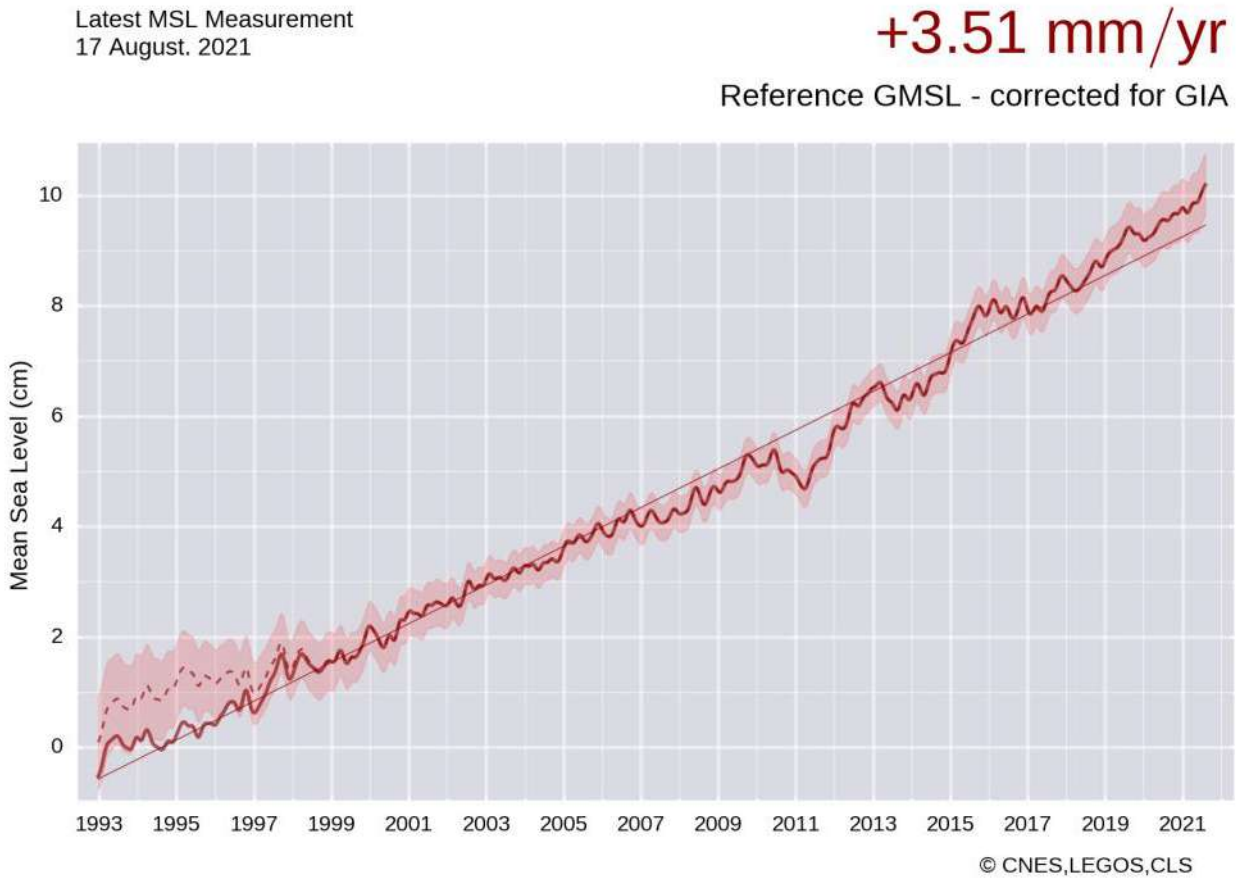
As global warming occurs, a direct reaction of the climate system is the rise in sea level. This is due to both seawater expanding in response to the temperature increase and addition of water from melting land-ice sheets and glaciers. The rise in sea level can be monitored by means of altimetry satellites that further our understanding of climate change and its socioeconomic consequences. The Global Mean Sea Level (GMSL) has thus become a key indicator of climate change.

This new version of the MSL Ocean indicator product is now based on the 2021 reprocessed L2P along-track AVISO+ products V03_00. The new products include **global MSL time series as well as regional MSL maps** covering the period 1993-to the present day, for the reference missions TopEx-Poseidon, Jason-1, Jason-2, Jason-3 as well as for the auxiliary missions Saral/Altika, ERS-1, ERS -2, Envisat and GFO-sat.

Key facts

- Use of the reprocessed L2P along-track V03_00 data,
- Improved SSH data and geophysical corrections,
- Extent of the Jason-3 reference timeseries,
- Regional MSL trend maps for Jason-3 and Saral/Altika missions,
- Updates of the GMSL reference timeseries uncertainties.

Product sheet interactive visualization tool, processing & corrections, references, … can be found **here**.



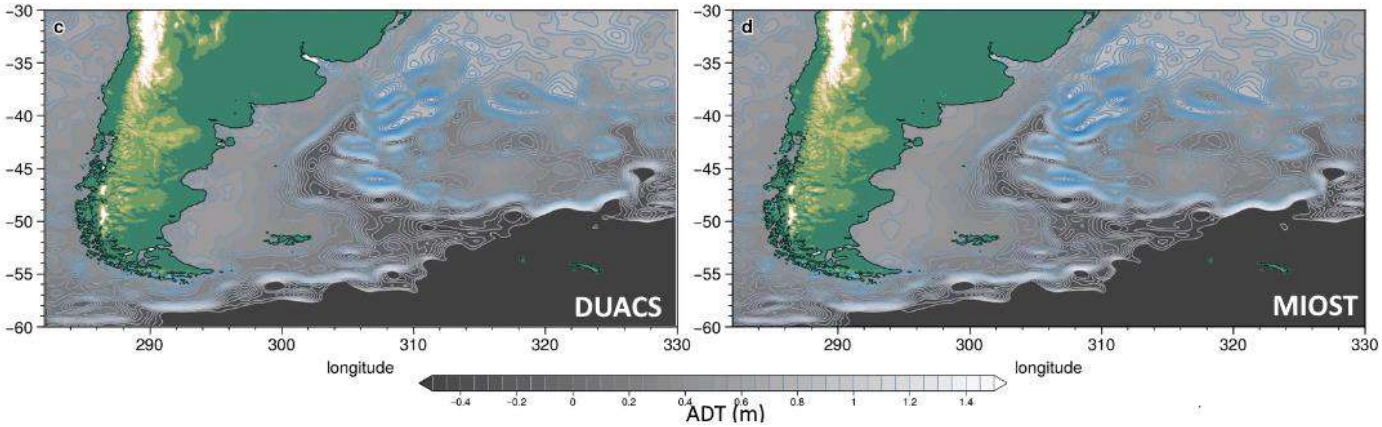
The reference global mean sea level (GMSL) based on data from the TopEx/Poseidon, Jason-1, Jason-2 and Jason-3 missions from January 1993 to the present day, after removing the annual and semi-annual signals and applying a 6-month filter. By applying the postglacial rebound correction (-0.3 mm/yr), the rise in mean sea level has thus been estimated to be 3.5 mm/year with an uncertainty of 0.4 mm/yr. Credits CNES/LEGOS/CLS.

Gridded maps with a new Multiscale Interpolation Method (MIOST)

AVISO+ Team

AVISO+ now offers new experimental gridded Ssalto/ Duacs maps over one year (2017) computed with the innovative **Multiscale Interpolation Ocean Science Topography** (MIOST) method described in Ubelmann et *al.*, 2021. This product aims at improving the mesoscale circulation resolution and users are encouraged to test this interpolation method in their studies.

Product sheet Characteristics, citation, references, … can be found **here**.



Comparative reconstructions of absolute dynamic topography derived from nadir altimeter merging techniques such as the operational DUACS system distributed by the Copernicus Marine Service (DUACS-CMEMS, left) and experimental Multiscales Inversion of Ocean Surface Topography mapping approach (right). Ubelmann et al., 2021, DOI 10.1029/2020JC016560, pdf. Watch animations here. Credits CNES/CSL/EU Copernicus Marine Service.

Monthly means of Eddy Kinetic Energy (EKE)

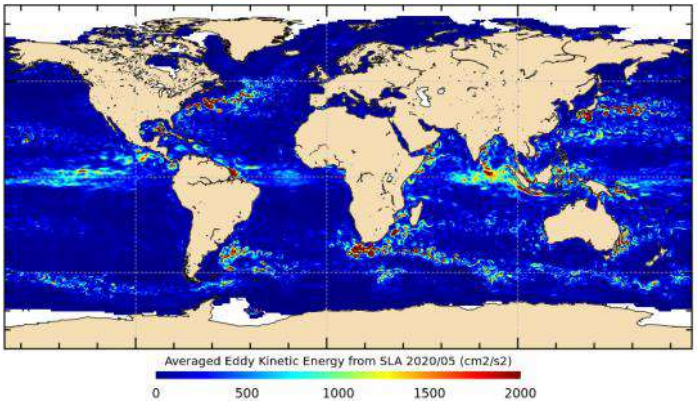
AVISO+ Team

From January 1993 to the last extension, the DUACS Delayed-Time gridded dataset allows computation of the statistical means of Eddy Kinetic Energy (EKE) over different periods of time.

Monthly Eddy Kinetic Energy (EKE) corresponds to the global daily grids at 1/4° of delayed-time eddy kinetic energy derived from sea level anomalies averaged, month by month from January 1993.

Multi-mission gridded eddy kinetic energy derived from sea surface heights computed with respect to a twenty-year mean profile [1993-2012], and including the seasonal variability (NB. The annual cycle is not removed).

Three areas are proposed: Global, Regional Mediterranean Sea, Regional Black Sea.



Climatology Map of EKE computing on May 2020. Credits CNES/CLS.

Product sheet: can be found here.

Events

OSTST meeting, Venice, Italy: 21-25 March 2022

EUMETSAT and CNES organize the next Ocean Surface Topography Meeting between 21-25 March 2022 (postponement of OSTST 2021) : « **Continued, enhanced ocean altimetry and climate monitoring from space** ». This meeting will include two related events : **OSTST** (21-25 March) and **International Doris Service Workshop** (21-23 March).

These will invlove a special splinter on the **Sentinel-6 Validation Team** (S6VT) feedbacks (chaired by the Project Scientists), a splinter on **Coastal Altimetry**, and a splinter on **CFOSAT**. In anticipation of the end of the Cal/Val phase of Sentinel-6A Michael Freilich, more than one year after the launch, abstracts that support this mission are highly encouraged.

Considering the current improvements regarding COVID related restrictions, the organising committee is confident to be in a position to have an in person meeting and continue preparing for it.

However, certain remote access functions will set up to give those of you who will not be able to travel access to all presentations, even if not in real time. At least two solutions will be provided:

i. The forums (as for OSTST 2020),

ii. And the recording of the sessions on-site that will be made available few days after the meeting.

The list and descriptions of the splinters is available here

All logistical information are available on a dedicated website, here.

Registration is open

Other events

February 27—March 2022 Hawaï, USA, Ocean Sciences

April 3-8, 2022 Vienna, Austria, EGU General Assembly

May 23-27, 2022 Bonn, Germany, Living Planet Symposium

AVISO+ Users Newsletter

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