



CNES OCEAN PROGRAM

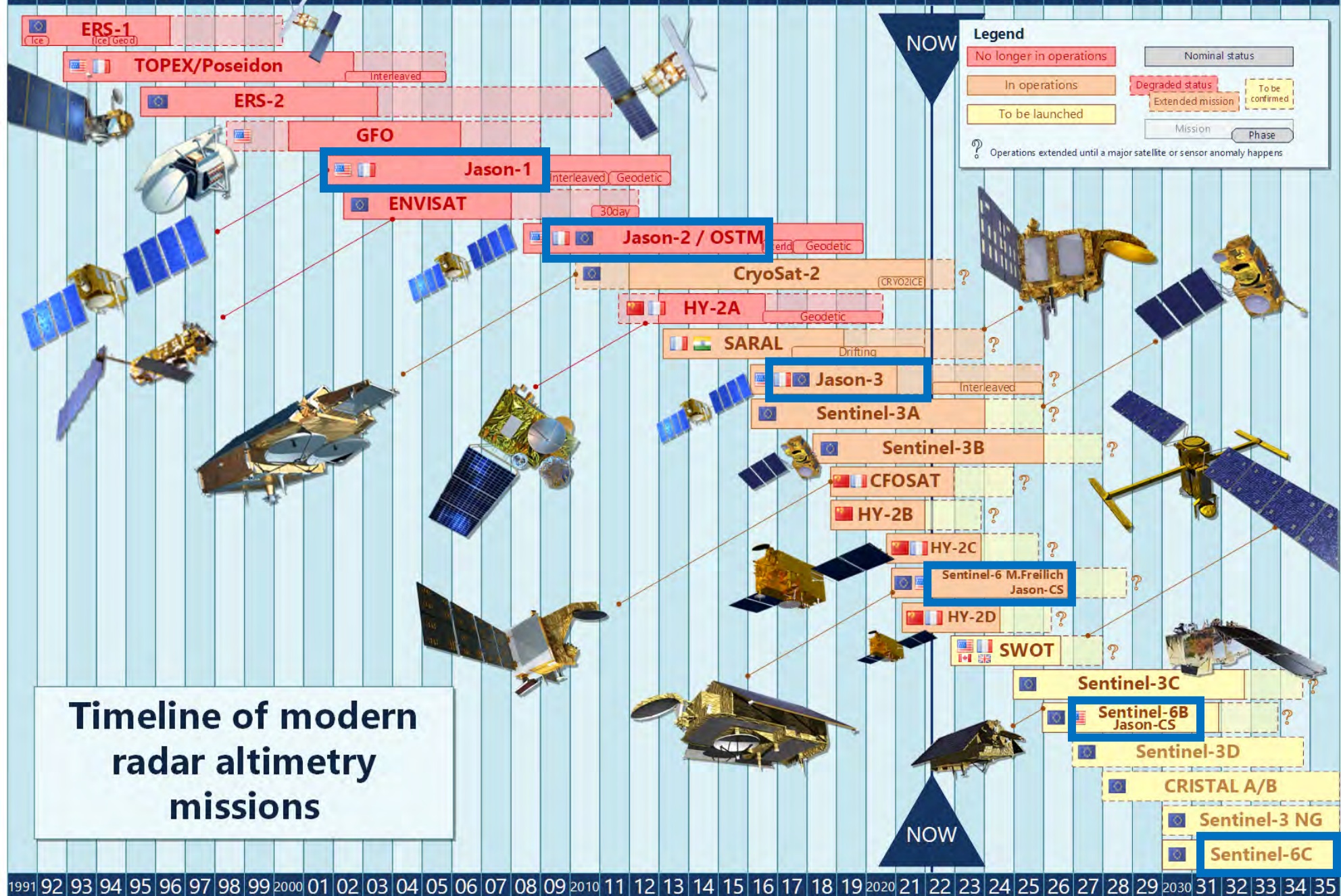
OSTST – VIRTUAL OPENING SESSION

March 21, 2022

Annick Sylvestre-Baron

CNES Ocean Program manager

1991 92 93 94 95 96 97 98 99 2000 01 02 03 04 05 06 07 08 09 2010 11 12 13 14 15 16 17 18 19 2020 21 22 23 24 25 26 27 28 29 2030 31 32 33 34 35



Timeline of modern radar altimetry missions

Reference altimetry satellite

CNES major actor for S6 altimetry performance

- SARAL: extension of mission for two more years
- CFOSAT : Extension of mission to be decided this year
- SWOT official date: NET 18 Nov. 2022



SARAL

Satellite with ARgos and ALtika

cnes

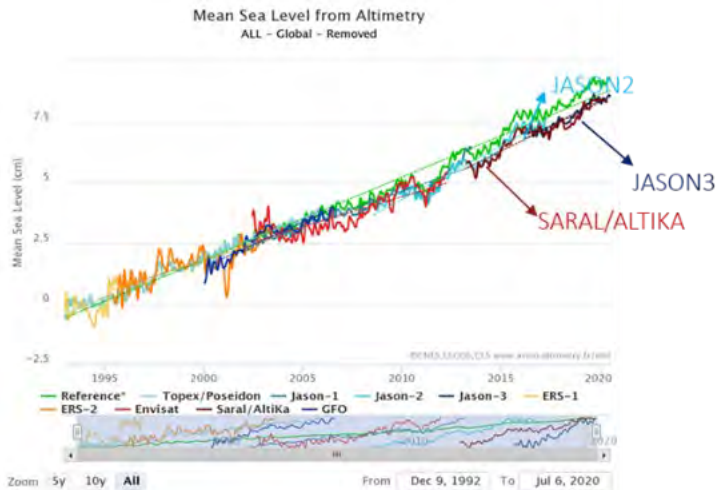
इसरो ISRO

EUMETSAT

Launch on Feb. 25, 2013

Third mission extension for 2 years -> Until End of 2023

Ka-band Altimetry - a «world premiere»



A step ahead towards the coast
Availability of valid SWH data from SARAL/AltiKa and Jason-2 for trains along 15 N showing better availability data near coast marked by Green line.

Improved detection of icebergs
Inland water

Implementation into operational oceanography systems
Hurricane tracking
9-h forecasted SWH overestimates SARAL wave height which is assimilated in the analysis

Better accuracy of Brahmaputra river flow rate monitoring w.r.t. Jason-2
Brahmaputra river along with Jason-2 and AltiKa tracks taken for the comparative analysis.

Overall relationship between observed versus reserved water level is taking into account all study tracks (a) AltiKa and (b) Jason-2

SARAL Analysis 9-hour FC

Richman & Jacobs, 2015
Griffiths et al., 2015

SWH from all PRS EACH product by SAC coastal product based on AltiKa.

Jason-2 results

ALtiKa

Jason-2

ALtiKa

Crossed SARAL

SWH (m)

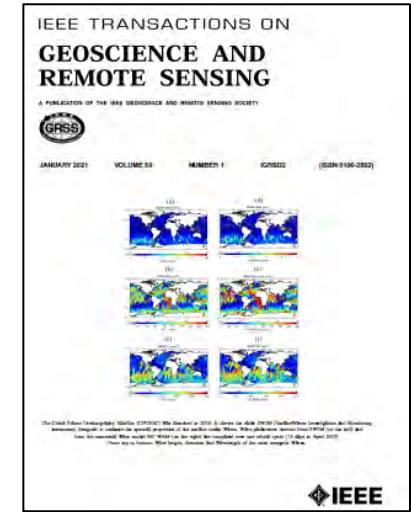
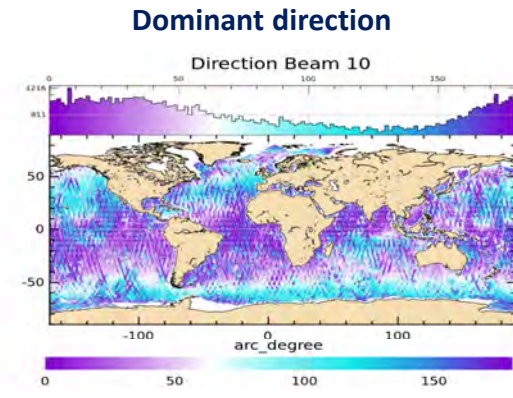
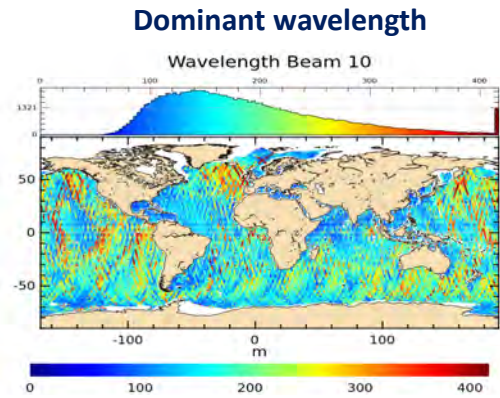
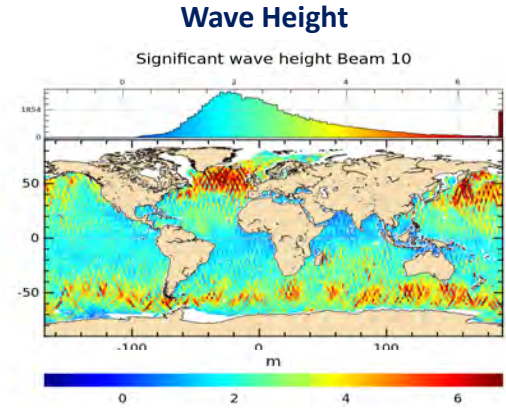
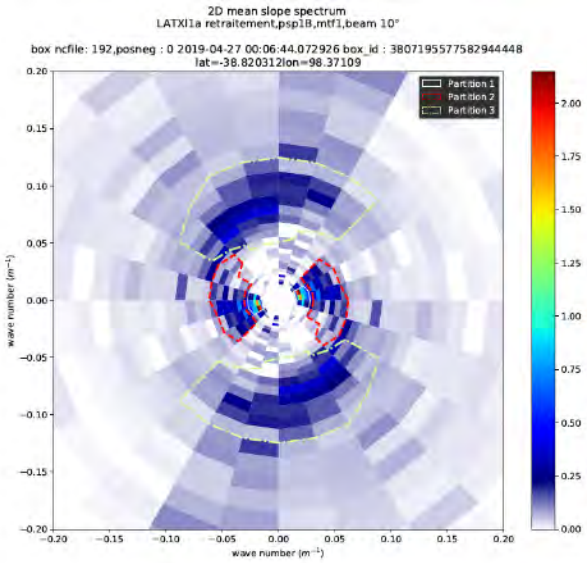
SWH (m)

SWH (m)



Launch on Oct. 29, 2018
First mission extension for 2 years to decide this year

Wave spectra: a «world premiere»



Reference paper on SWIM
 (Hauser et al, 2021)

<https://aviso-data-center.cnes.fr/>
<https://resources.marine.copernicus.eu/>

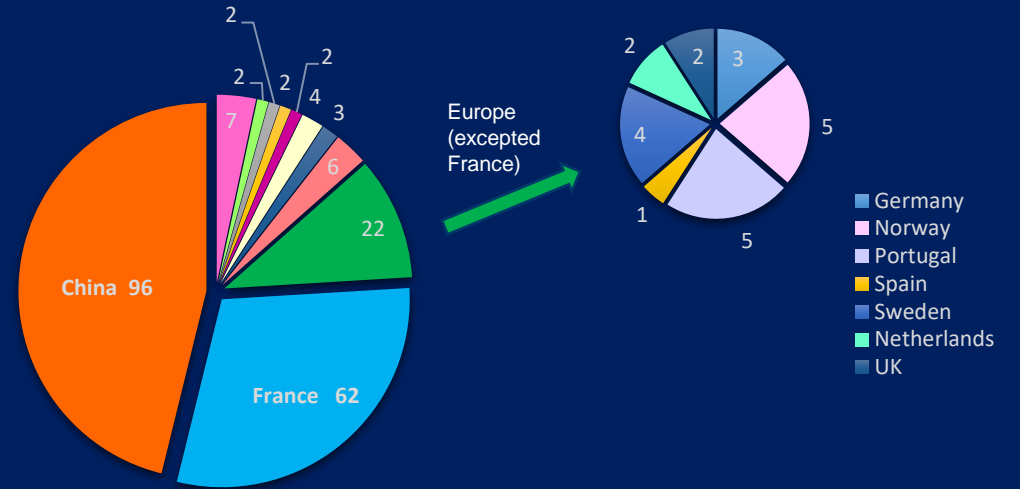


1st International Science Team selected in 2018 (2019-2022)



**208 members
from 17 countries**

- Australia
- Canada
- India
- Corean
- Mexico
- New-Zeland
- Russia
- US
- Europe (excepted France)
- France
- China



- ❖ CNSA and CNES will to renew the CFOSAT ST for 2023-2027
 - ✓ Call release on April 2022- Proposal due date on June 2022
 - ✓ Selection in Fall 2022
 - ✓ Call Information will be distributed to OSTST

- Scientific topics of interest in the context of this CFOSAT call are numerous :
 - ✓ Ocean surface wind and waves analysis (climatology, extreme conditions), characterization, modeling
 - ✓ Interaction, impact of waves with other geophysical parameters and phenomena
 - ✓ Coastal areas, characterization of wave fields forcing coastal processes, ...
 - ✓ Sea ice characterization (SWIM and SCAT), waves in sea ice, ...
 - In addition, secondary objectives which can benefit from the original observation configuration (continental ice shelf, characterization of bare soil properties or vegetation)
- For all these studies, the combined use of data from different sources is encouraged.

If « waves » is a topic of interest for you,
join the CFOSAT team via the incoming call



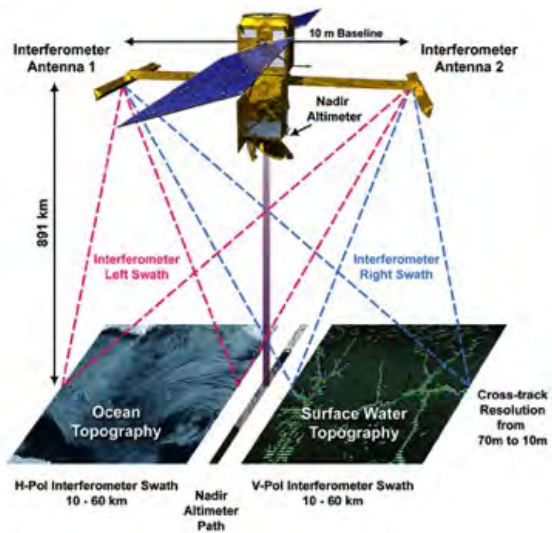
SWOT



THE mission to be launched this year ! *Not Early than Nov. 18, 2022*

Wide-swath Altimetry - a «world premiere»

Thanks to the teams who work hard to have SWOT in flight before end of this year !



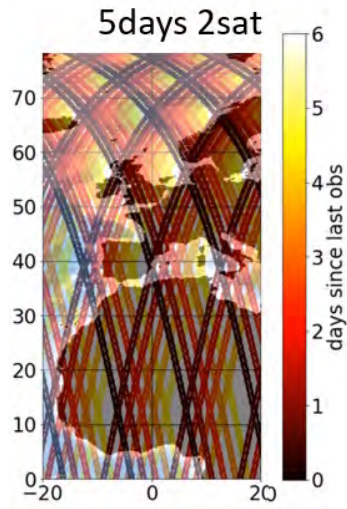
Promising results from SWOT ST and early adopters

Strong motivation of ocean, hydro and coastal communities to have SWOT data

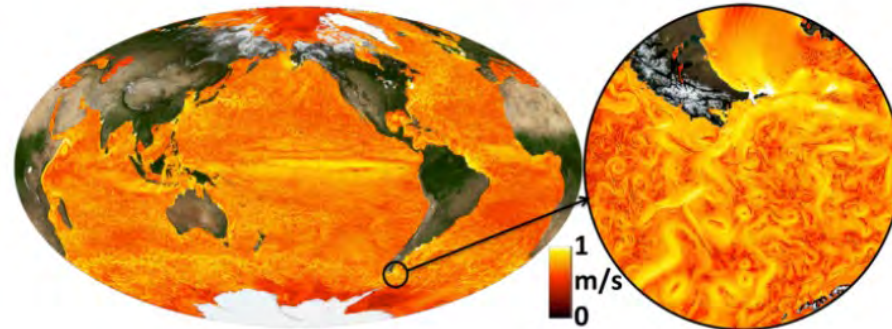


CNES High priority ocean topics for the coming years

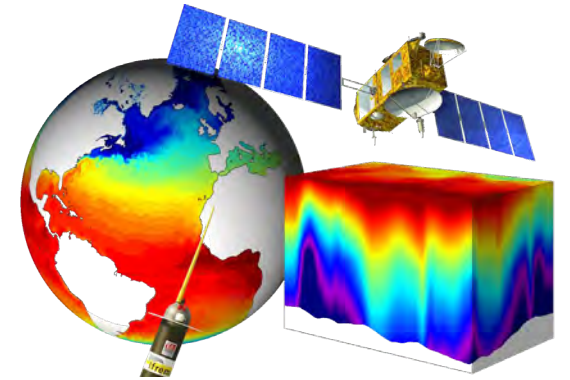
Operational wide-swath mission



Currents mission

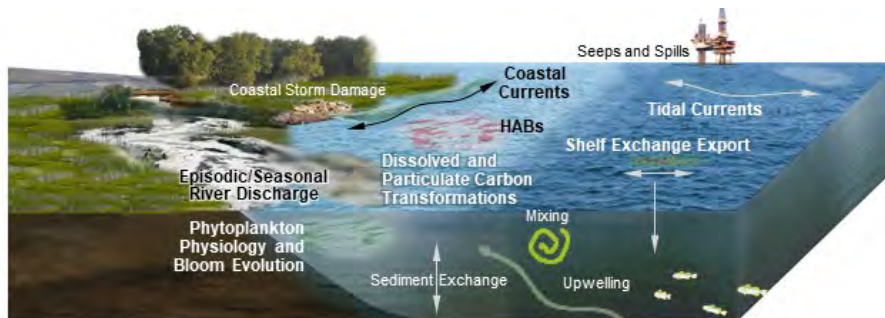


Global Ocean Color mission



Areas of strong challenge

Coastal



Polar areas



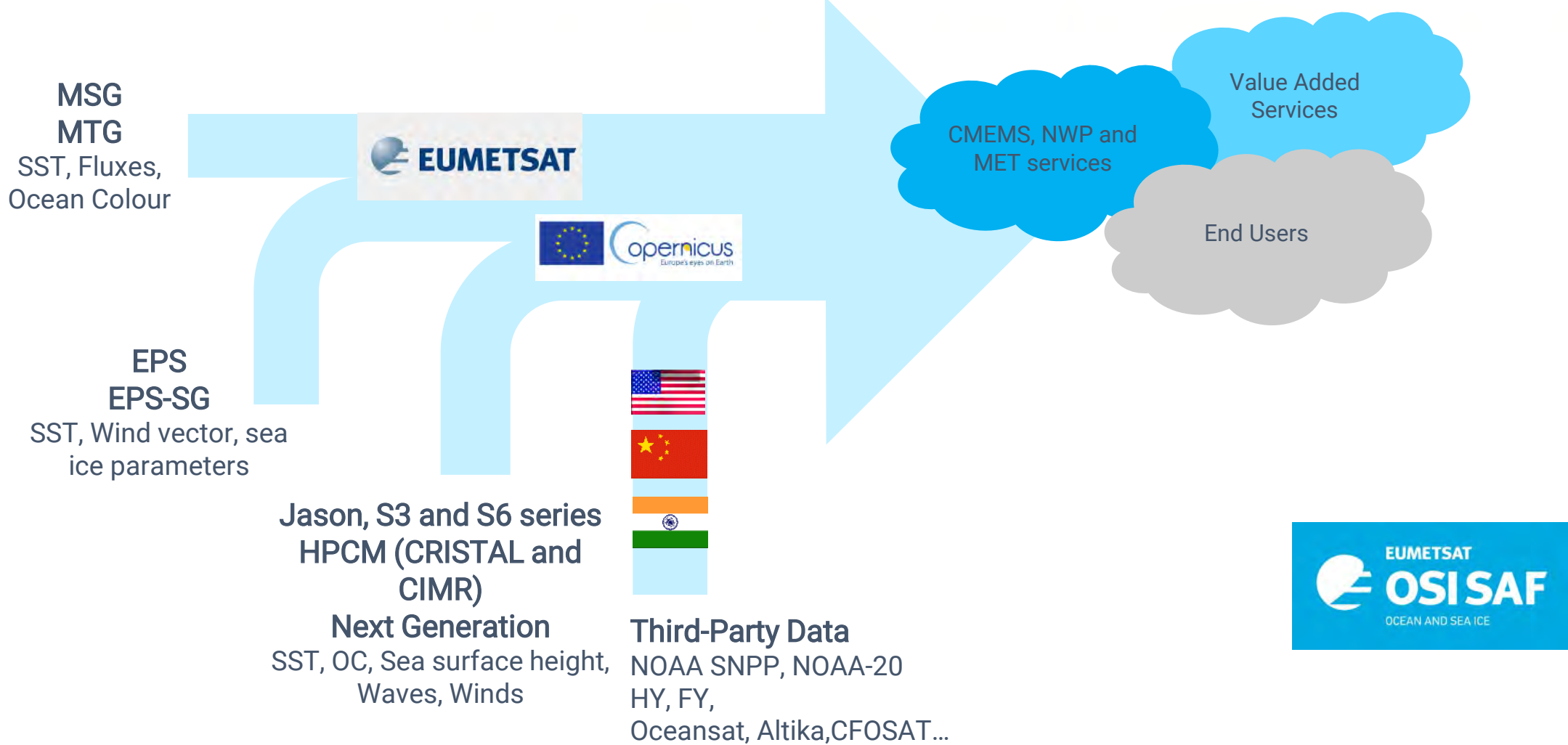
OSTST 21 March 20022

A growing integrated stream of marine products

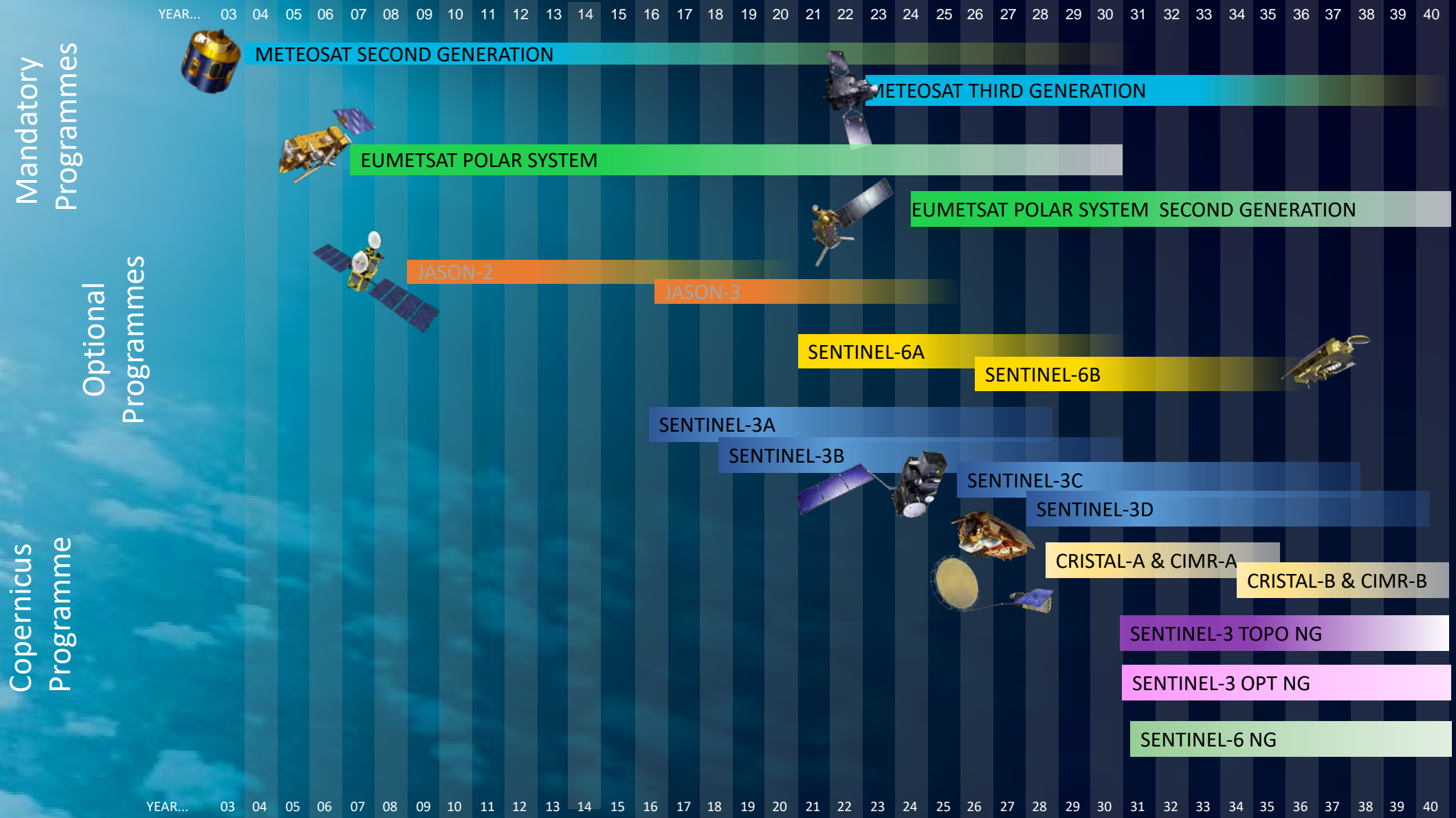
Estelle Obligis

EUMETSAT marine data flow

Operational delivery of Copernicus, EUMETSAT and Third-Party data

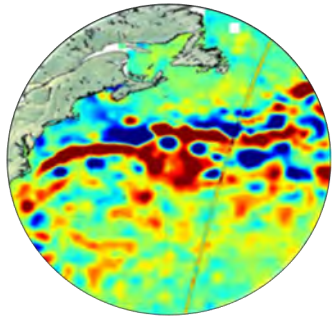


A busy and exciting program for the years to come...

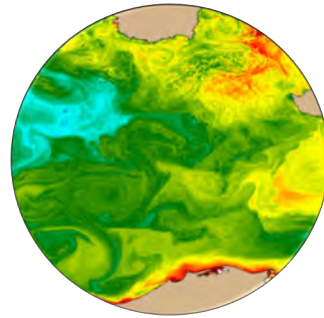


Be the provider of reference products for operational oceanography

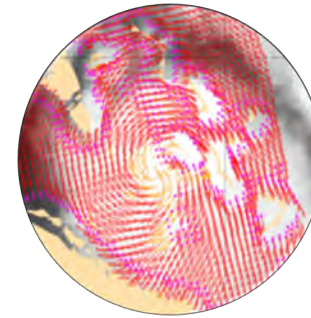
EUMETSAT aim at releasing reference products for ocean observations needed by its users



Altimetry products
with Sentinel-6 as a
foundation element
for an operational
integrated multi-
mission framework
combining S6, S3,
CRISTAL, NG.



SST products
from Sentinel-3 SLSTR
as reference products
endorsed by the
international
community
represented by
GHRSSST.



Wind products
from ASCAT / SCA
scatterometers with
absolute calibration
to support
operational
oceanography and
climate monitoring.



Ocean Colour products
from Sentinel-3 OLCI with
state of the art
processing, the
development of the
Copernicus Ocean Colour
Vicarious Calibration
System and of GEO
products from EUMETSAT
missions.

EUMETSAT and oceanography in Copernicus 2.0

EUMETSAT plans to operate and generate products from:

Sentinel-3 NG

TOPO : continuity and enhancement topography

OPT : continuity and enhancement of Ocean Colour and SST products

Sentinel-6 NG

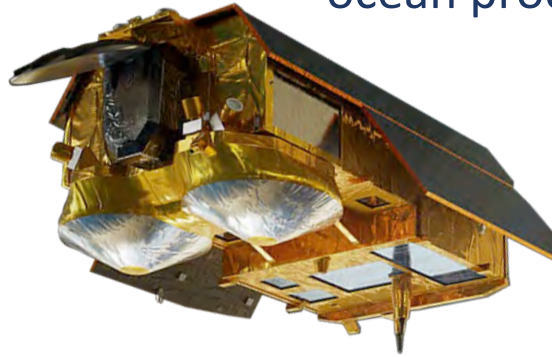
Continuity of reference mission for altimetry

CRISTAL

Altimetry mission focused on polar caps from which EUMETSAT will generate global ocean products

CIMR

Microwave mission focused on polar caps from which EUMETSAT will generate global ocean products (SST, winds, salinity, ...)



Data Access to wider User community : WEkEO

WEkEO is the Copernicus DIAS (Data and Information Access Service) reference service for environmental data, virtual processing environments and skilled user support.

WEkEO was developed and implemented by EUMETSAT, ECMWF and Mercator Ocean, in a stepwise approach, minimizing the risks, capitalizing on user feedback, and strongly involving the industry through procurement.



Implemented by



Program Status (NOAA)

Chris Sisko (Program Manager)

Eric Leuliette (Program Scientist)

Ocean Surface Topography Science Team Meeting (OSTST)

21-22 March 2022

Virtual meeting



TOPEX/Poseidon
1992-2006

Jason 1
2001-2013

OSTM/Jason 2
2008

Jason 3
2016

Sentinel-6A
2020

Sentinel-6B
2025



NOAA Support of the OSTST

Four PIs funded for the 2021-2024 Team (\$800K/year)

- In Fiscal Year 2021 the NOAA Office of Ocean Exploration and Research provided matching funding through the National Oceanographic Partnership Program (NOPP)



Investigator	Institution	Title
James Carton	University of Maryland	Improving Tropical Cyclone Intensity Forecasts by Assimilating Ocean Surface Drifter paths with altimeter sea level
Alejandro Egido	Global Science & Technology, Inc.	Reconciliation of High- and Low-Resolution Ocean Altimeter Measurements Under Changing Surface Wave Structure Conditions
Sinead Farrell	University of Maryland	High-Latitude Multi-Altimeter Observations of the Arctic Ocean and its Sea Ice Cover
John Wilkin	Rutgers University	Mesoscale to submesoscale ocean state estimation by 2-way nested 4-dimensional variational data assimilation

<https://www.star.nesdis.noaa.gov/socd/lsa/OSTST.php>

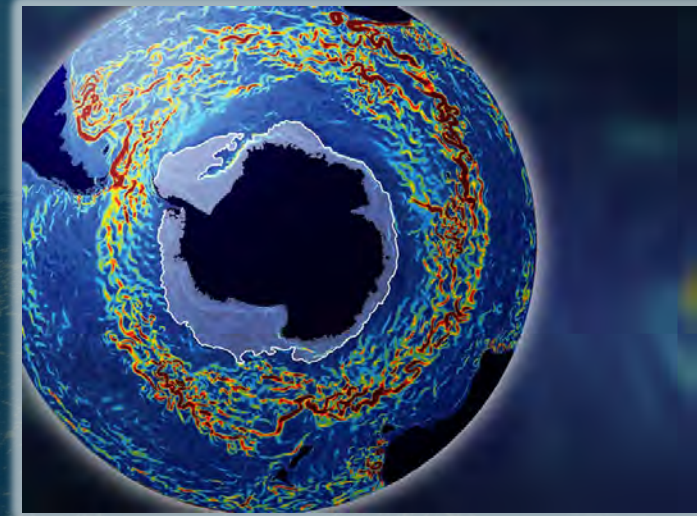
ESA Programmes

Jérôme Benveniste

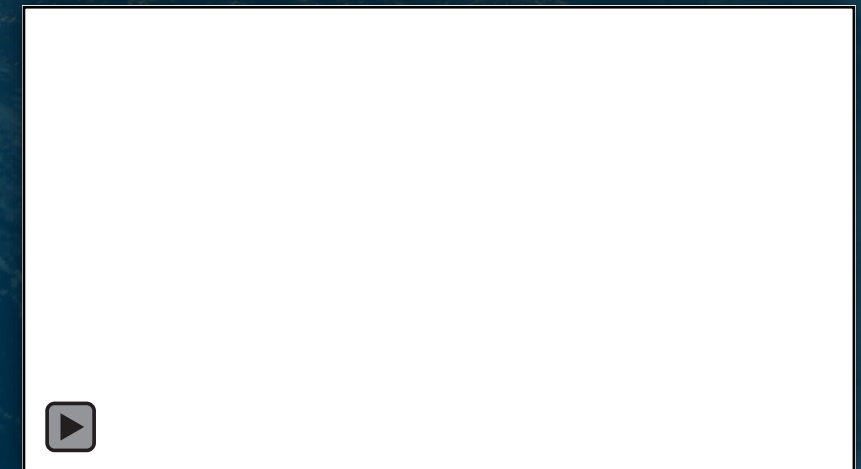
OSTST Virtual Interim Meeting

21-22 March 2022

- The overall performance of the mission is **excellent**
- The current fuel leakage rate will force to switch to the redundant Reaction Control System in May 2023 to guarantee operations beyond 2028
- The mission extension until December 2025 has been endorsed by ACEO, DOSTAG and PBEO. The extension will be authorised as part of the CMIN decisions in November 2022
- CryoVex 2022 campaign is about to start and will be followed by an Antarctic campaign in autumn/winter 2022, focussing on #CRYO2ICE. As a result, the orbit of CryoSat will be changed in June 2022 to maximise CryoSat-2/ICESAT-2 coincident ground tracks over the South Pole: <https://cryo2ice.org>
- A new Ocean Baseline D will be released end of this year.
- Reprocessing of Baseline Echo ice is about to start.
- Version 1 products of CRYO-TEMPO were released in January 2022 <http://www.cpom.ucl.ac.uk/cryotempo/index.php?theme=polaroceans>
Version 2 is expected to be released by end of this year.



Antarctic Circumpolar Current from Ocean circulation model (Credit: Mazloff, MIT; Source: Supercomputer Center, UC San Diego)



S3NG-T Mission Aim and Objectives

Mission aim and Objectives stem from the analysis of User needs and LTS

Target is to **guarantee the continuity of S3 today**

SSH and derivatives, Hs, U10, Sigma0, sea ice, land ice, river and lakes...

Then, to enhance S3 and address:

Sampling and coverage → time AND space sampling (#1 User Need – for everyone working with altimetry)

Hydrology sampling and performance (now primary Objective by EC request)

Provide new products to meet evolving Copernicus User Needs.

ESA UNCLASSIFIED – For ESA Official Use Only

4 S3NG-T MISSION AIMS AND OBJECTIVES

4.1 S3NG-T Mission Aim

Considering the User needs expressed by the European Commission and concisely articulated in the previous sections, the aim of the Copernicus Next Generation Sentinel-3 Topography (S3NG-T) Mission is:

To ensure continuity of Sentinel-3 in flight performance topography capability in the 2030-2050 timeframe.

4.2 S3NG-T Objectives

Mission requirements are then derived from mission Objectives.

The primary objectives of the S3NG-T mission are to:

- PRI-OBJ-1.** Guarantee continuity of Sentinel-3 topography measurements for the 2030-2050 time frame with performance at least equivalent to Sentinel-3 in-flight performance as defined in Table 2.4-1 ('baseline mission').
- PRI-OBJ-2.** Respond to evolving user requirements and improve sampling, coverage and revisit of the Copernicus Next Generation Topography Constellation (S3NG-T and Sentinel-6NG) to ≤50 km and ≤5 days (CMEMS, 2017) in support of Copernicus User Needs.
- PRI-OBJ-3.** Enhance sampling coverage, revisit and performance for Hydrology Water Surface Elevation measurements in support of Copernicus Services.
- PRI-OBJ-4.** Respond to evolving user requirements and enhance topography Level-2 product measurement performance.

The secondary objectives⁹ of the S3NG-T mission are to:

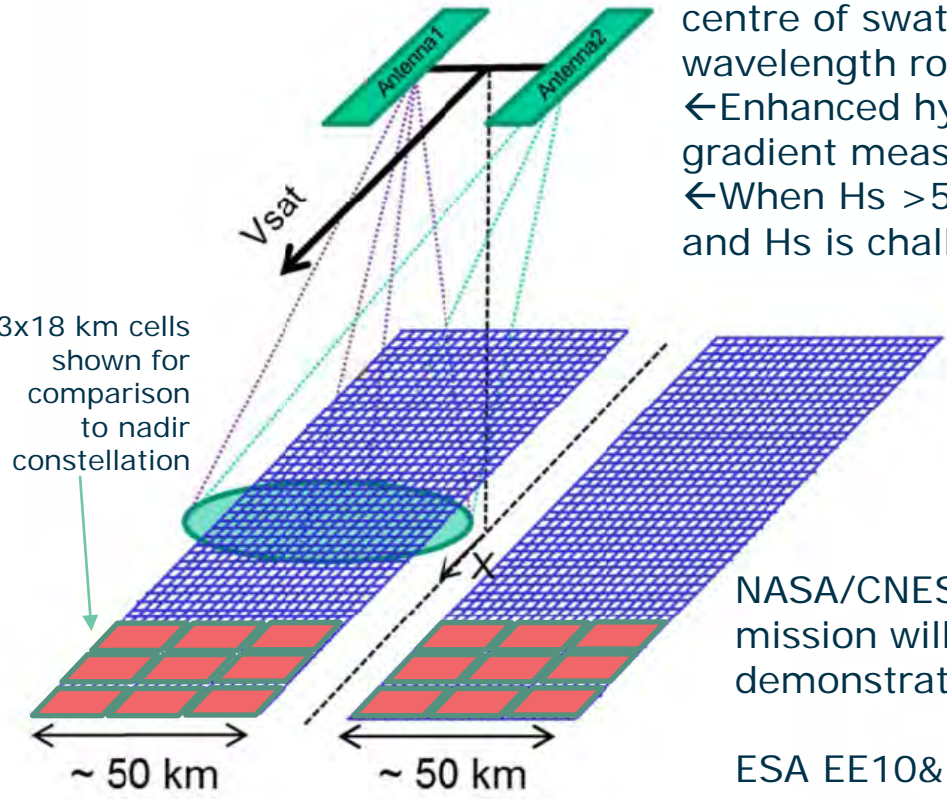
- SEC-OBJ-1.** Provide directional wave spectrum products that address evolving Copernicus user needs.
- SEC-OBJ-2.** Provide new products¹⁰ that address evolving Copernicus user needs.

ESA Phase-0: S3NG-T #1 REQ Sampling

(potential configurations to compare “like with like (revised)”)



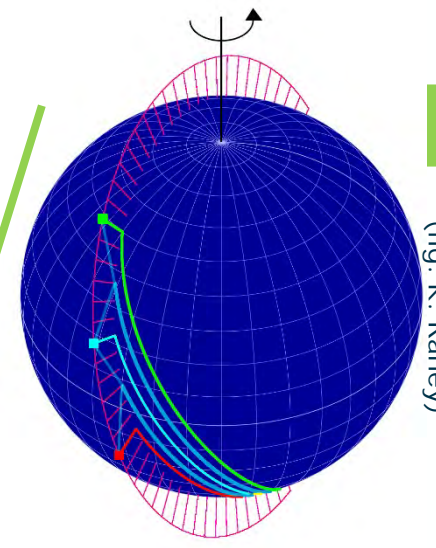
- ← 18km (TBC) ka-band (SAOO) for ocean surfaces (higher native posting)
- ← Ku-band Nadir altimeter required at centre of swath for Hs and long wavelength roll error.
- ← Enhanced hydrology and ocean height gradient measurement
- ← When Hs > 5m performance in (SSH) and Hs is challenged



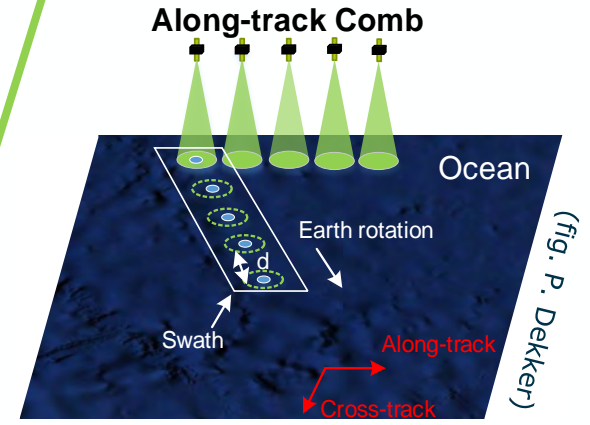
NASA/CNES SWOT R&D mission will be the first demonstration in 2023+

ESA EE10&EE12 Harmony and SeaStar mission concepts) also relevant

Constellation of 2-3 **swath altimeter satellites**



← Resolution ~0.3km along track x 5-6 tracks (Hs dependent). Option for FFSAR processing in range (ambiguities).



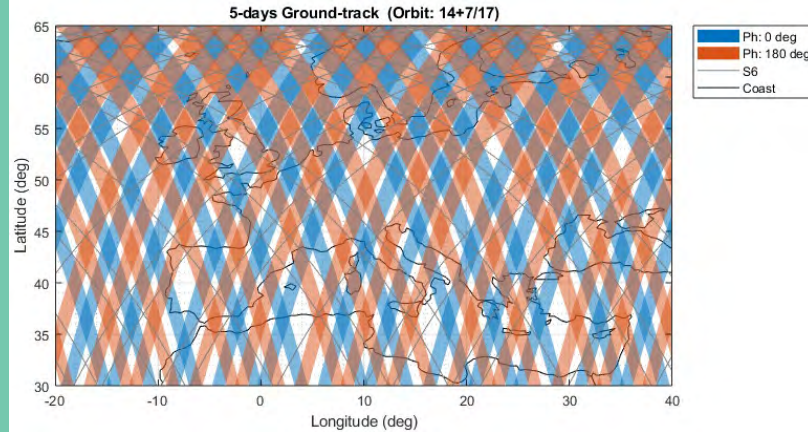
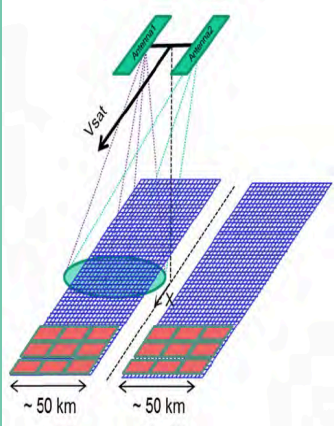
Ka-band SAR provides an equivalent solution to swath AND meets all continuity performance across swath (configurable)

Scalable, and well understood.

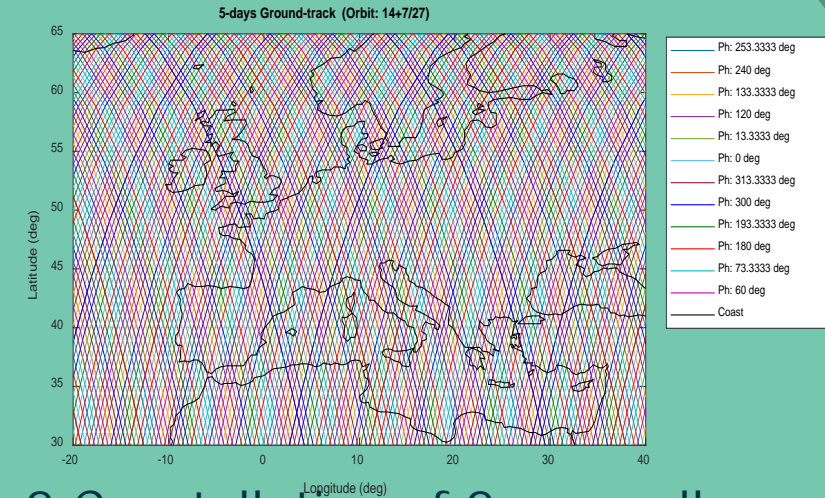
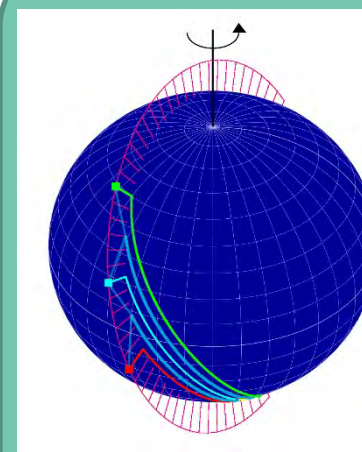
Similar to CNES SMASH concept for Hydrology

Constellation of 10-12 small **nadir pointing satellites**

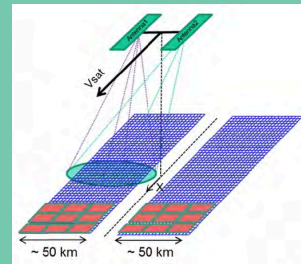
Sentinel-3 Next Generation (Topography) Phase A/B1



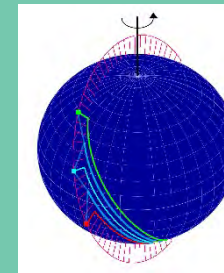
Option 1: Constellation of 2..n **swath altimeter satellites**



Option 2 Constellation of 2..n small **nadir pointing satellites**



+



Option 3: Hybrid of nadir and **swath altimeter satellites**



S3NG-T Status

- Phase-0 2020/21: Complete
- Mission Advisory Group Established Nov 2021
- Mission Requirements Document and System Requirements Document prepared for Phase A/B1
- Phase A/B1 Procurement complete – 2 Consortia Kicked off March 2022

- Preliminary Concept Review (PCR) in Summer 2022: Down-selection of concept options to just one
- MRD available on request from Mission Scientist (Craig.Donlon@esa.int)

CRISTAL – a Copernicus Expansion mission



Objectives: Monitor sea ice, icebergs, land ice, glaciers, but also ocean, coastal zone and inland waters

High inclination mission (91.5 deg), continues the legacy of CryoSat-2, with improved performance

Dual-frequency Ku/Ka SAR altimeter, Ku is interferometric

Improved bandwidth: 500 MHz in both Ku and Ka

- Open burst over sea ice and icebergs → improved resolution
- Flexible open loop/closed loop tracking
- AMR-CR radiometer with HRMR for oceanography, coastal altimetry, ice classification

Status: completing system PDR
 About to start Phase C
On track for CRISTAL-A launch in 2027

	Open ocean (OCO) SAR CB	Sea Ice & Icebergs (SII) SARIn OB		Land Ice & Glaciers (LIG) SARin CB		
		Sea Ice	Icebergs	Ice sheet interior (Ice sheet / Ice cap)	Ice margin	Glaciers
Measurement mode in Ku	SAR-CB	SARIn Open-Burst		SARIn-CB		
Measurement mode in Ka	SAR-CB	SAR Open-Burst		SAR-CB		
Range window size	256 pts	256 pts	256 pts	1024 pts	1024 pts	1024 pts
Tracking window size	256 pts	256 pts	256 pts	2048 pts	N/A	N/A
Range window size	64 m	64 m	64 m	256 m	256 m	256 m
Tracking window size	64 m	64 m	64 m	512 m	N/A	N/A
Tracking mode	Open-loop	Closed/Open-loop	Closed/Open-loop	Closed/Open-loop	Closed/Open-loop	Closed/Open-loop
On-board processing	RMC	N/A	N/A	N/A	N/A	N/A

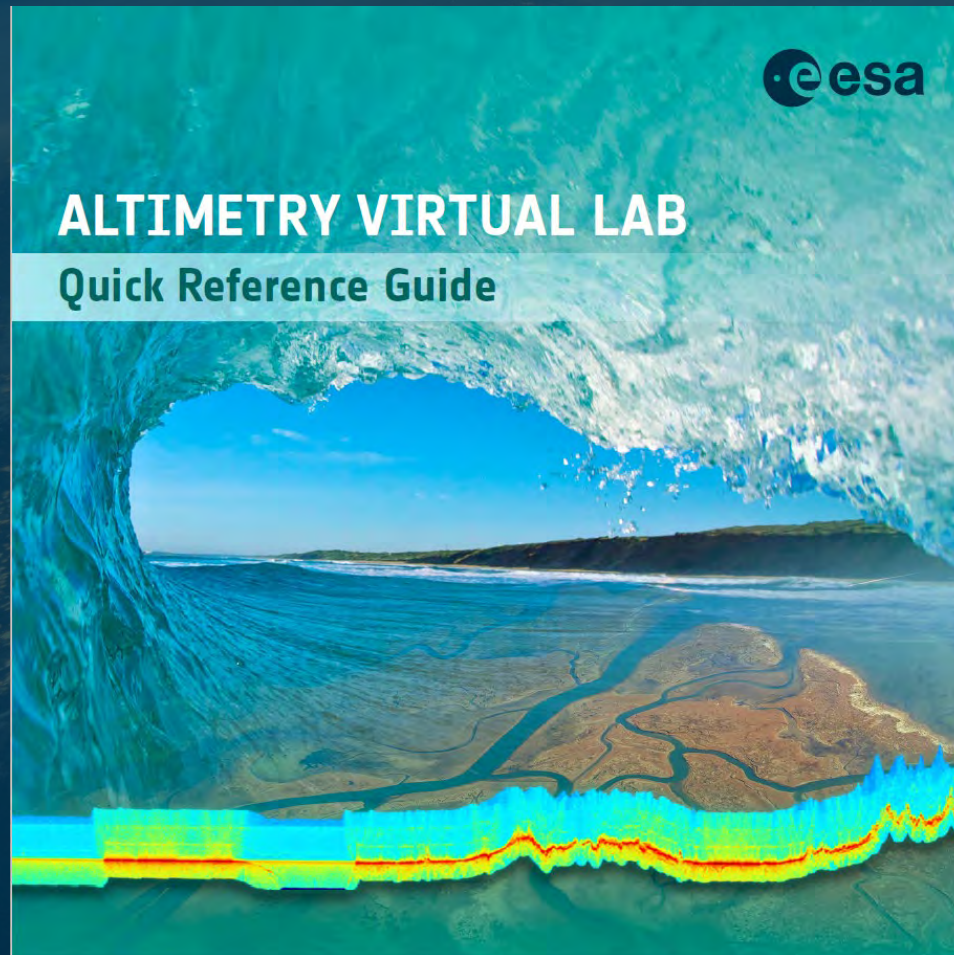
ESA Altimetry Virtual Lab Processors for SAR Altimetry Missions at the EarthConsole[®]

The sequel of the GPOD/SARvatore

The EarthConsole® Altimetry Virtual Lab, funded by ESA, aims at providing a virtual space to:

- **Support the Altimetry community in the development of new Earth Observation applications;**
- **Access a set of tools to share information and results with colleagues:**
 - **Altimetry Processors, forum, datasets repository, and a knowledge-base with relevant altimetry publications and media**
- The Altimetry Virtual Lab has been developed on the new EarthConsole® platform and hosts the SARvatore (**SAR Versatile Altimetric TOolkit for Research & Exploitation**) family of processors which was previously available in the ESA Grid Processing On-Demand (G-POD) environment. The Altimetry Virtual Lab ensures service continuity following the recent termination of the G-POD environment.
- The driving concept is to offer the same processing capabilities formerly available in ESA G-POD while improving the user experience by combining:
 - Access to innovative, fully customizable, altimetry data processing services from a single environment at the push of a button;
 - Availability of a set of tools to network with colleagues, keep up with the latest news and publications on radar altimetry, and share results to avoid duplication of efforts;
 - Flexibility of a virtual space which can be further reshaped following the future emerging needs of the community.

Instructions in the brochure: <https://earthconsole.eu/knowledge-base/>



THE ALTIMETRY VIRTUAL LAB SERVICES VIA THE ESA NoR

All Altimetry Virtual Lab services are available via the **Network of Resources (NoR)**, an ESA initiative aiming at facilitating the use of cloud environments. Research, development, or pre-commercial project may be eligible to receive a voucher to exploit the EarthConsole@ Altimetry Virtual Lab services free of charge or at very competitive prices.

If you will select the option **ESA NoR Sponsorship=yes** in the service request form, EarthConsole@ operators will prepare the NoR sponsorship form and share it with you for review and approval. To learn more about the NoR mechanism, please click on the ESA Sponsorship page of the EarthConsole@ website.



CONTACTS & ACKNOWLEDGING

For any further information on the Altimetry Virtual Lab, please contact info@earthconsole.eu with support@earthconsole.eu and altimetry.info@esa.int in cc. In case of technical assistance with any of the services, please contact support@earthconsole.eu with altimetry.info@esa.int in cc

Acknowledging the Altimetry Virtual Lab/SARvatore services and EarthConsole@ when showing or publishing results obtained through their use is recommendable and appreciated. Users can contact altimetry.info@esa.int with support@earthconsole.eu in cc to share and discuss results and agree on a proper citation.

The SARvatore Altimetry Virtual Lab Software User Manual can be downloaded from: https://earthconsole.eu/wp-content/uploads/2021/10/SARvatore-AVL-EarthConsole-AVL_Software_User_Manual.pdf

Altimetry Virtual Lab Users can:

- Request & access, through the G-BOX service, a virtual machine for algorithm development, testing and post-processing analysis. Each virtual machine also includes software for altimetry data analysis & visualization: BRAT (<http://www.altimetry.info/toolbox/>), Panoply (<https://www.giss.nasa.gov/tools/panoply/>) and Python;
- Request to access and process data with the following processors which have been integrated and are ready for use:

ALES+ SAR Retracker – developed by the Technical University of Munich,

FF-SAR (Fully Focused SAR) for CryoSat-2 – developed by Aresys srl,

SARINvatore for CS-2, SARvatore for CS-2, SARvatore for S3 – developed by the ESA-ESRIN Altimetry Team

TUDaBO SAR-RDSAR – developed by the University of Bonn.

All processors can be requested for both bulk (P-PRO service) or on-demand (P-PRO ON DEMAND service) processing;

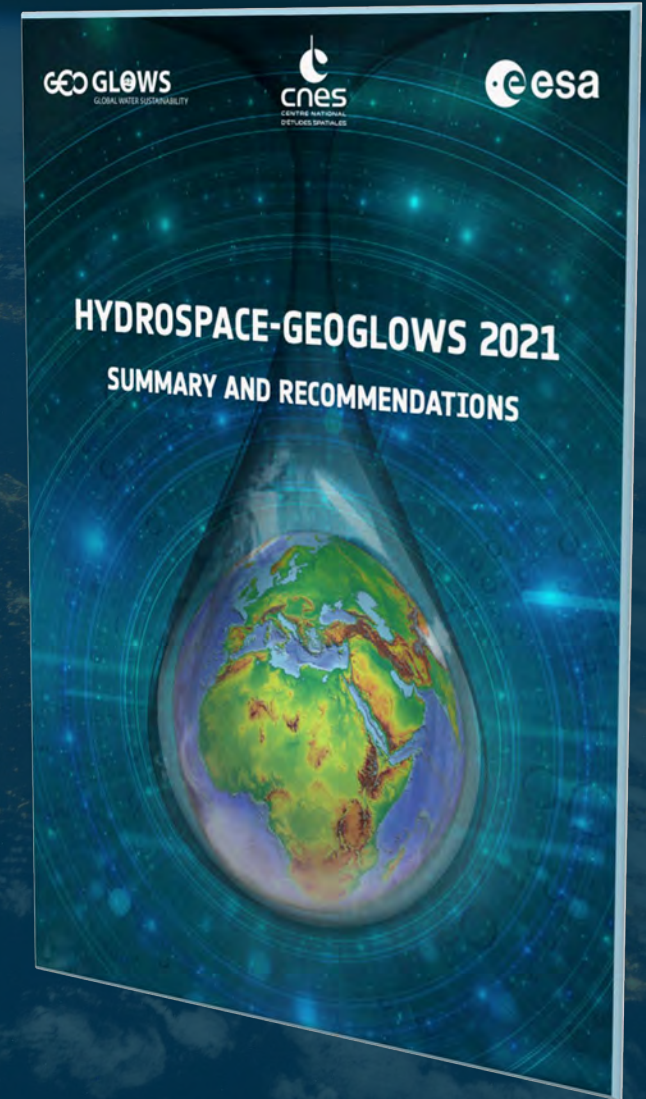
- Request to integrate, through the I-APP service, additional processors;

Access a set of tools to network and share information and results with colleagues: a forum, a datasets repository, and a knowledge-base with relevant altimetry publications and media for consultation;

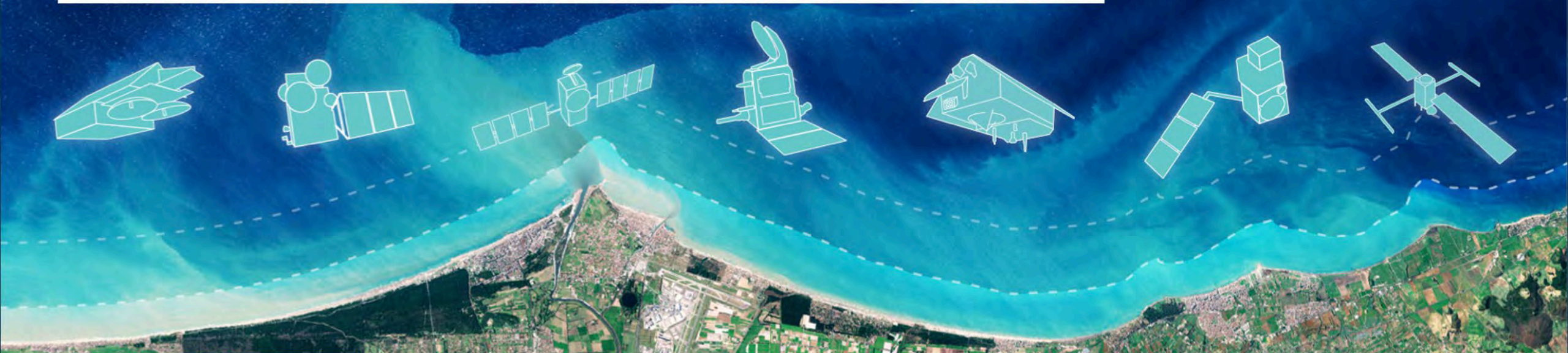
THE HYDROSPACE-2021 REPORT IS PUBLISHED

It contains a **MANIFESTO**
including an address to Space Agencies

Benveniste, J., A. Andral and A. Gutierrez (Eds.), Organising Committee and Session Co-Chairs (2021), Summary and Recommendations from the HYDROSPACE-GEOGLoWS 2021 Workshop, ESA Publication, <https://doi.org/10.5270/esa.hydro-space-geoglows-2021-report>



→ 13th COASTAL ALTIMETRY WORKSHOP



www.coastalaltimetry.org

CAW-13 is planned for FEBRUARY 2023 in CÁDIZ, SPAIN

<https://www.coastalaltimetry.org>