NADYA VINOGRADOVA SHIFFER

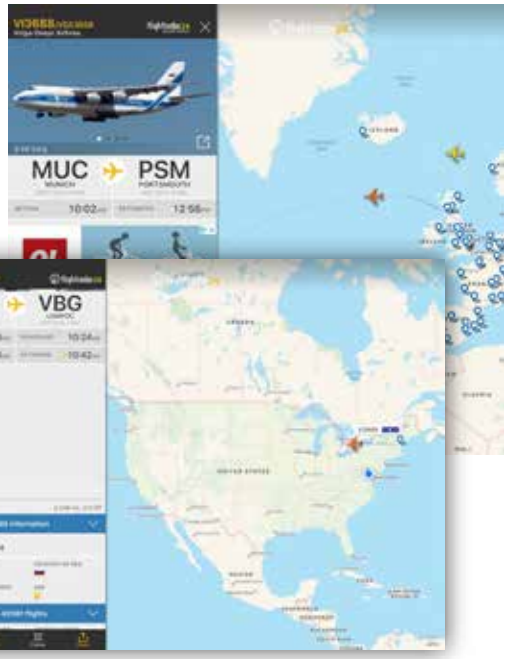
NASA HQ · Science Mission Directorate

OSTST Meeting

October 19 - 23, 2020

Sep-22-2020: S6 MF started to move. Spacecraft leaving IABG test facility in Munich, Germany

Sep-23-2020: Volga-Dnepr AN-124 carries spacecraft MUC – PSM – VBG



Sep-24-2020: S6 MF spacecraft landed at VAFB, California

Go Sentinel-6 Michael Freilich!

- S6 MF is at the launch site VAFB, California
- Kudos to space engineers at Airbus and JPL

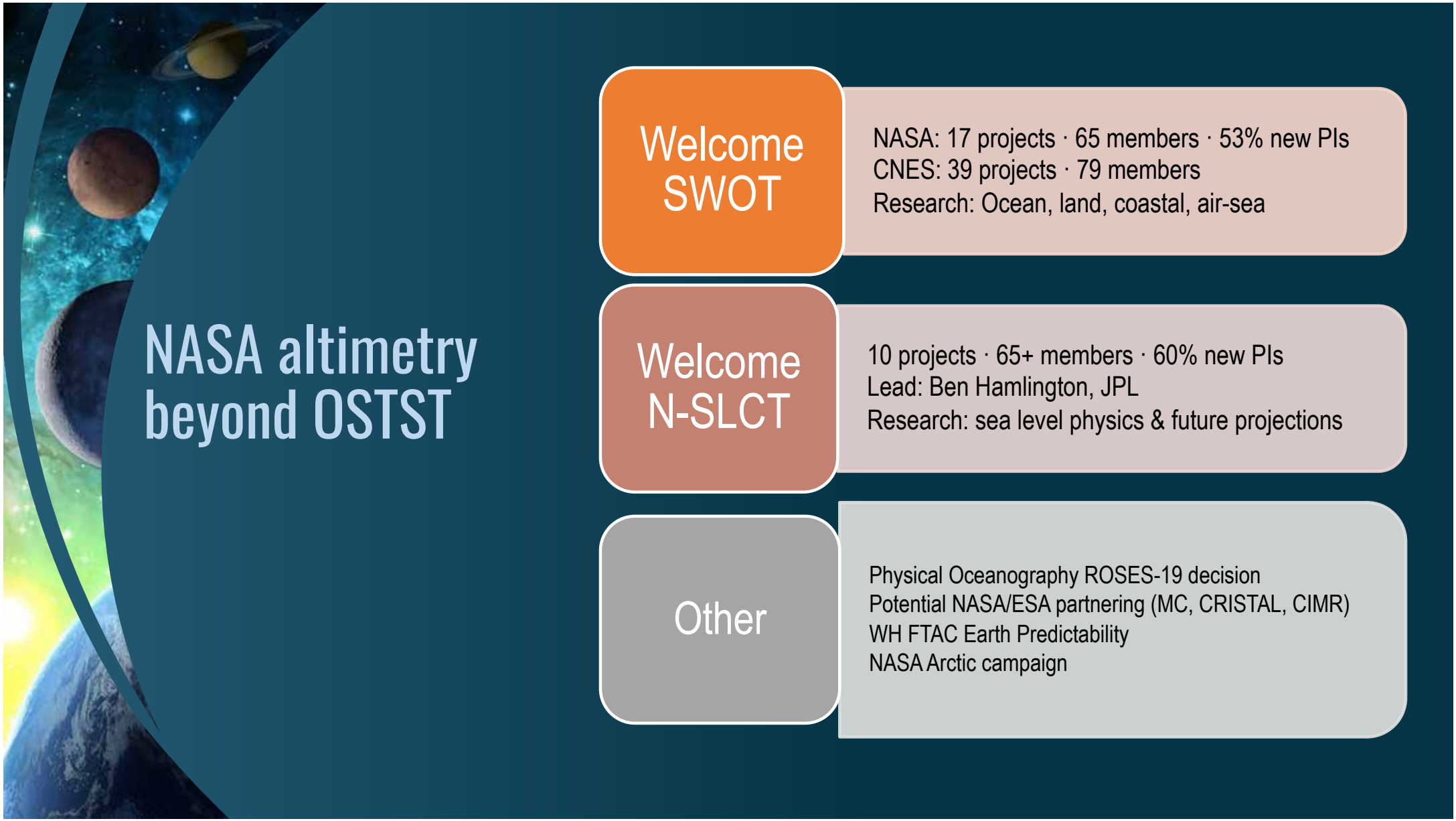
  Thank you, essential workers!
- Successful NASA KDP-E on October 13, 2020
- OSTST competition timeline (NASA & NOAA):

  October 8, 2020 – proposals due

  Today – review process underway

  April 2021 – new projects start,

  discoveries of Sentinel-6 era begin!



NASA altimetry beyond OSTST

Welcome SWOT

NASA: 17 projects · 65 members · 53% new PIs
CNES: 39 projects · 79 members
Research: Ocean, land, coastal, air-sea

Welcome N-SLCT

10 projects · 65+ members · 60% new PIs
Lead: Ben Hamlington, JPL
Research: sea level physics & future projections

Other

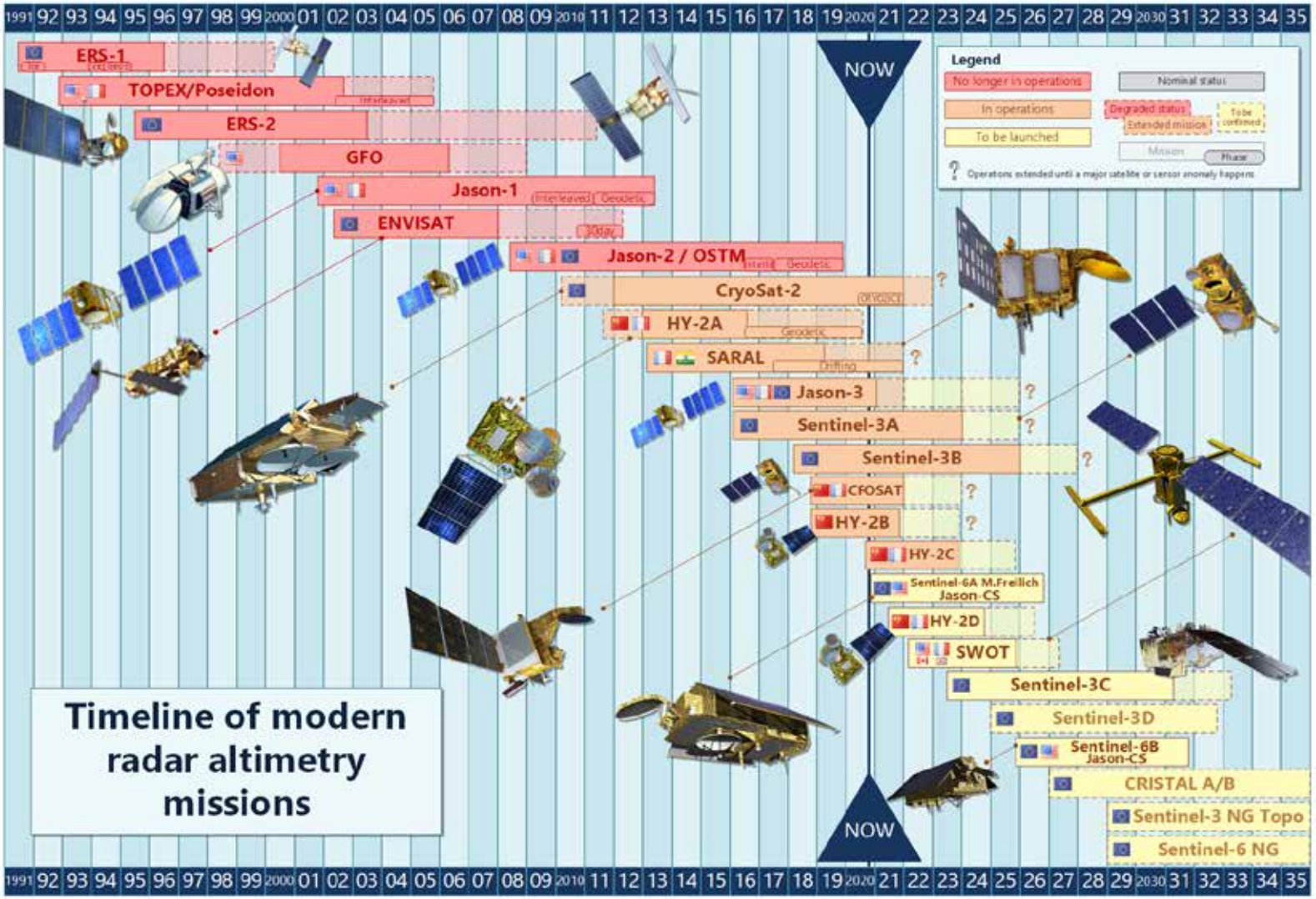
Physical Oceanography ROSES-19 decision
Potential NASA/ESA partnering (MC, CRISTAL, CIMR)
WH FTAC Earth Predictability
NASA Arctic campaign

CNES ocean Program status

Annick Sylvestre-Baron, *Ocean program*
With contribution of Sophie Coutin-Faye, *Altimetry projects*
& Thierry Guinle, *in orbit Altimetry missions*

19th of October, 2020

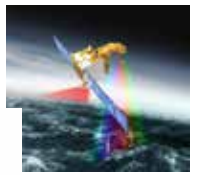
OSTST – Virtual opening session



- **HY2-A: End of data acquisition in Sept 14, 2020 - CNES Altimetry data activities and DORIS support ended**
- **Jason-3: Extension for 5 more years**
- **HY2-C: Launched in Sept. 21, 2020**
- **S6A Michael Freilich: launch on Nov. 10, 2020**
- **SWOT official date: Feb 2020**

❑ In orbit satellites

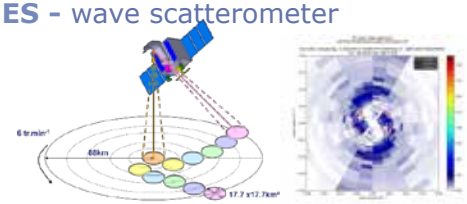
CFOSAT: China France Oceanography SATellite (10/29/2018 -)



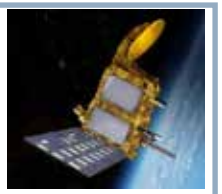
- **Two payloads: SCAT / CNSA** - wind scatterometer - **SWIM / CNES -** wave scatterometer

→ **All data released to science community since Feb 2020**
→ **L3 SWH CFOSAT available on CMEMS catalogue**

(*see today presentation and dedicated CFOSAT splinter)*



SARAL: Satellite with ARgos and ALtika (02/25/2013 -)



→ **Current drifting phase**
→ **Ka-band allows glaciology, hydrology and geodetic research & applications**

(see today presentation)

JASON3 (16/01/2016 –)

→ **Since Nov. 2016, Jason-3 is the altimetry reference mission**
→ **Still on historical TOPEX/Poseidon orbit – After at least a tandem with Jason Michael Frielich (JASON-CS), Jason-3 will change to a TBD orbit (EOL OSTST group action)**
→ **Officially extended by program partners for 5 more years**

(see today presentation)

❑ Multi-mission exploitation

Missions operations:

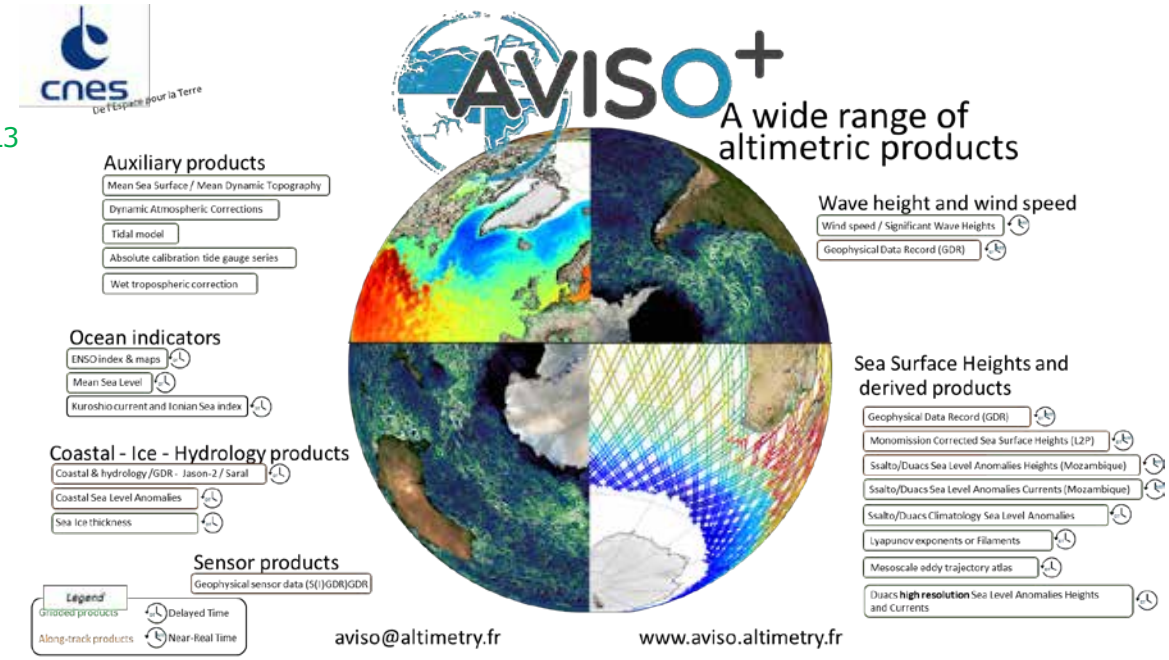
- SARAL OK > 99 % availability
- Jason-3 OK > 99% availability
- HY2-B - Nominal quality of data and nominal availability. L2 products available from CNSA. L3 in CMEMS catalogue since this summer.

DORIS and POD

- Same + Hy-2C, Cryosat-2, Sentinel-3 A/B
- Reprocessing of past and in-flight missions using new standards

Beyond GDRs:

- L2P products for CMEMS
- GDR-F coming soon for Jason-3 (Oct. 29)
- GDR-F reprocessing complete for SARAL
- Experimental R&D products (along-track, gridded, eddy atlas…)
- Expertise studies
- OSTST science projects



❑ Missions in development

Copernicus:

- Contribution to Sentinel-3 & Sentinel 6/ Jason CS (TOPO performance, DORIS/ POD, level L2P & L3 products)
- Continuing support to science studies through OSTST

HY-2 ocean series

- HY2-D to be launched in 2021
- HY2-E & HY2-F & HY2-G planned
- DORIS on all HY2 (excepted HY2-B)
- CNES in charge of POD and altimetry data performance expertise

SWOT

- **TOSCA SWOT Science Team call managed by CNES**
  - 39 projects were selected:
    - 21 from French entities and 18 from foreign entities (excepted US entities selected by ROSES call)
    - 21 ocean, 12 Hydro and 6 coastal
- **ROSES and TOSCA ST members selection**
  - 137 members: 48 from US entities, 51 from French entities and 38 from foreign entities located in 15 different countries

❑ Future Missions

➢ High priority missions for CNES Earth/Ocean observation

Mission	Observation	Scientific objectives	status
MARVEL	Gravity field	Evolution of climate, Solid Earth, water mass. Earth reference system	Collab: NASA/ ESA
SKIM	Ocean Winds and currents	High frequency observation – ECV: Total Current Surface	EE9**:** Not selected

➢ CNES Strong support to Altimetry long term and other auxiliary ocean topics:

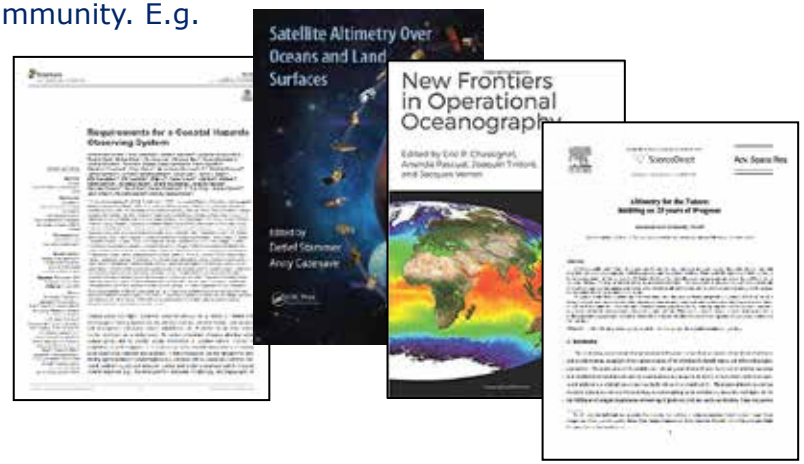
- WISA (Phase 0 studies in support to the definition of Sentinel-3 Next Generation): medium swath altimetry and hydrology
- STREAM (new mission concept with heritage from SKIM - proposed at EE11 call): Ocean Currents & Winds
- CRISTAL (science support): cryosphere, sea ice, ocean and Inland water
- CIMR (science support): polar ocean (SST, SSS ….)
- ULID (Nanosat) & SMOS-HR: Salinity

❑ Joint CNES/EUMETSAT TOSCA OSTST call ongoing

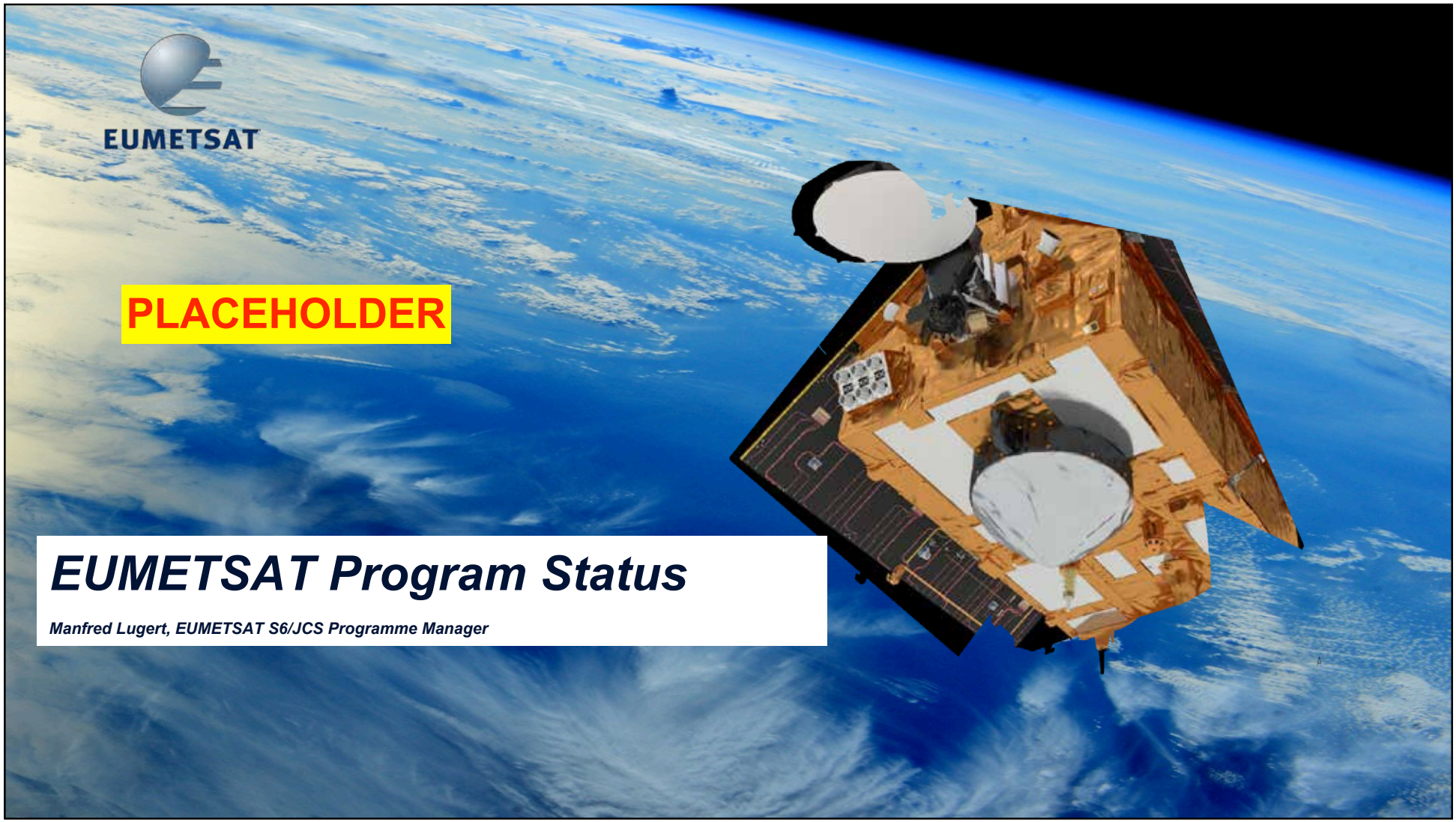
❑ CEOS OST-VC action status (last presentation done during 2019 OSTST closure session)

- Update of the "Next 15 years of altimetry – OST Constellation User Requirement Document", 2009
  http://ceos.org/observations/documents/Satellite_Altimetry_Report_2009-10.pdf

- Integrate new user needs (included specific recommendations from the CEOS COAST team, ESA NG-TC MATER and) from recent books and white papers from the community. E.g.



- Deliver a new OST-VC White Paper Document (action OST-VC-19-06) **by Q4 2021 (new deadline)**
  - ✓ **OSTST will be be solicited in 2021**
    - For specific contributions in their area of expertise
    - For overall review of the first draft
  - ✓ Remaining parts will be done by the OST-VC members under CNES/Eumetsat coordination.



EUMETSAT Program Status

Manfred Lugert, EUMETSAT S6/JCS Programme Manager

Program Status (NOAA)

Chris Sisko (Program Manager)

Eric Leuliette (Program Scientist)

NOAA Jason Ground System (NJGS)

NJGS Network Upgrade/Refresh

- **Network connectivity and Jason data flow transition was completed using multi-mission high-speed trans-Atlantic link between Darmstadt and U.S. NOAA network (NWAVE)**
  - includes secure and diverse routing into and out of NOAA networks
  - increase in the network performance and greater network transparency over traditional dedicated circuits
  - enabled redundancy connections into Fairbanks station (terrestrial and microwave) and multiple diverse routes into Wallops station
    - capacity increase to Barrow supporting Jason-3 increased as well for additional support flexibility

NJGS Technical Refresh

- COVID-19 impacts to schedule and technical work materialized
- New technical team set up and progress on the tech refresh integration continues
- The tentative schedule for completion and operational deployment is early-to-mid 2021

NOAA Support of the OSTST

Five PIs funded for the 2017–2020 Team

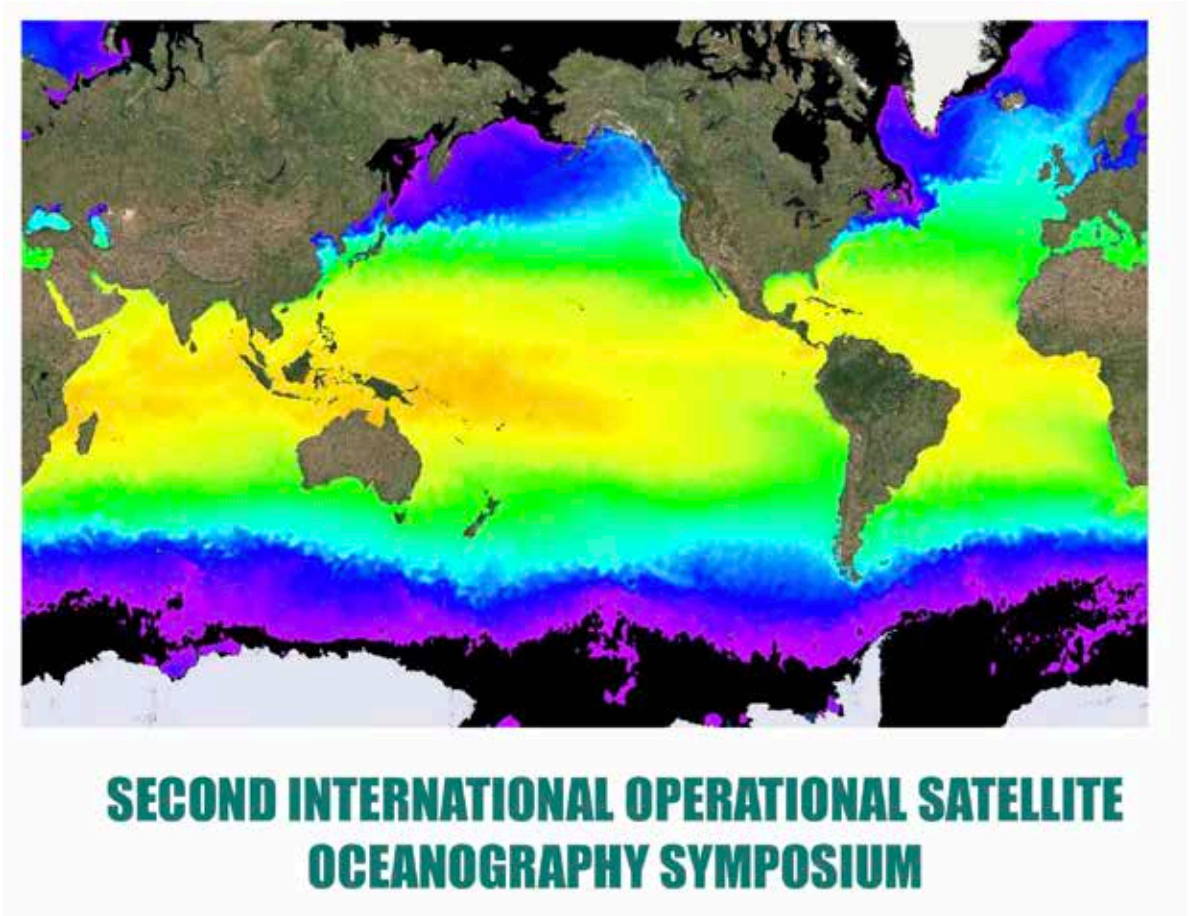
- Arctic circulation, EKE, Fully-Focused SAR, Data Assimilation, and air-sea interaction
- Funded through NOAA Cooperative Institutes

Support the 2021-2024 OSTST in the 2020 ROSES (deadline 8 October 2020)

- 3–4 investigations, total ~$500K/year

CISESS

2nd Operational Satellite Oceanography Symposium



Darmstadt, Germany
25–27 May 2021

optional training
28 May

Abstract Submission:
15 January 2021

Registration:
10 April 2021

ESA's Earth Observation Programmes

Ocean Surface Topography Science Team Meeting (OSTST) 2020
Online, 19-23 October 2020

Jérôme Benveniste
with contributions from many ESA colleagues:
Clément Albergel, Jérôme Bouffard, Craig Donlon, Mark Drinkwater,
Pierre Féménias, Michael Kern, Tommaso Parrinello, Marie-Hélène Rio et al.

Outline – 5’ to cover...

The "ESA Programmes status" report covers all Programmes/Projects linked to Altimetry excluding S3 and S6MF (later in the agenda):

- CryoSat Mission status and new products/new applications
- SMOS Mission new products/new applications
- Copernicus polaR Ice and Snow Topography Altimeter Mission (CRISTAL)
- Copernicus Imaging Microwave Radiometer (CIMR)
- Copernicus Next Generation Topography Constellation (NG-TC)
- ERS/ENVISAT products revamping
- EO4Society/FutureEO
- CCI+ Sea Level, Sea State, Lake, Sea Level Budget Closure
- GPOD/SARvatore – SAR Altimetry Virtual Lab status

A successful Track-Record

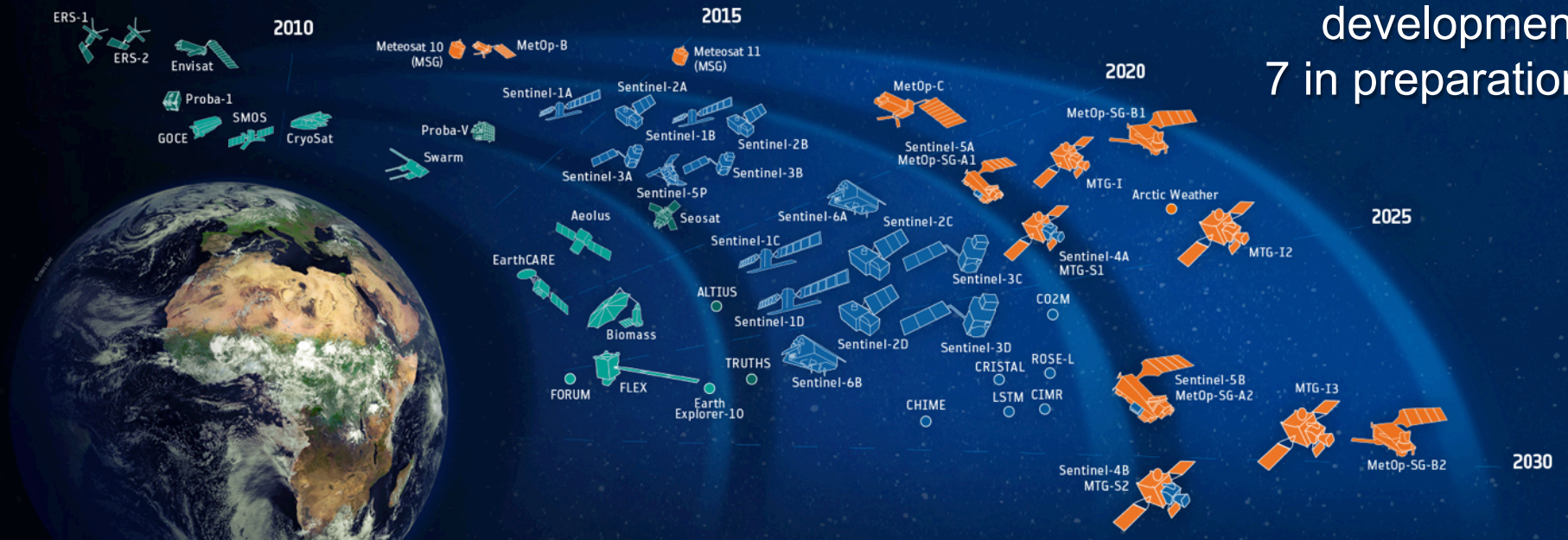
ESA-Developed Earth Observation Missions

Satellites

15 in operation

34 under development

7 in preparation

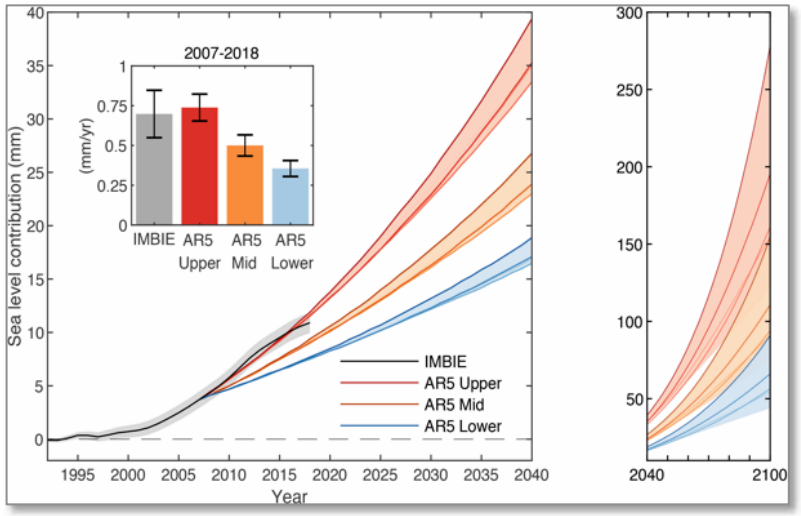


Science esa | Copernicus | Meteorology EUMETSAT

European Space Agency

CryoSat Mission Status

- On the 8th April 2020, CryoSat celebrated 10 years in operations. The mission has been providing one decade of high quality data to understand the cryosphere and the hydrosphere with contributions to key climate change indicators and operational services
- The overall performance of the mission remains in **excellent condition**, above design specifications
- The 11th **In-flight Operation Review** confirmed that all CryoSat lifetime critical items allow to continue operations until end of 2022 for which, programmatic funds have just been confirmed
- The root cause of the fuel leakage has been found. Mitigation actions are currently under discussion taking into consideration also the timeline of the CRISTAL launch.
- Products are continuously evolving taking into consideration new user requirements and innovative studies
- The **#CRYO2ICE** campaign, which raised the CryoSat-2 orbit by one kilometre to achieve the "19/20 synchronization" with NASA's ICESat-2, took place seamlessly (see next slides)

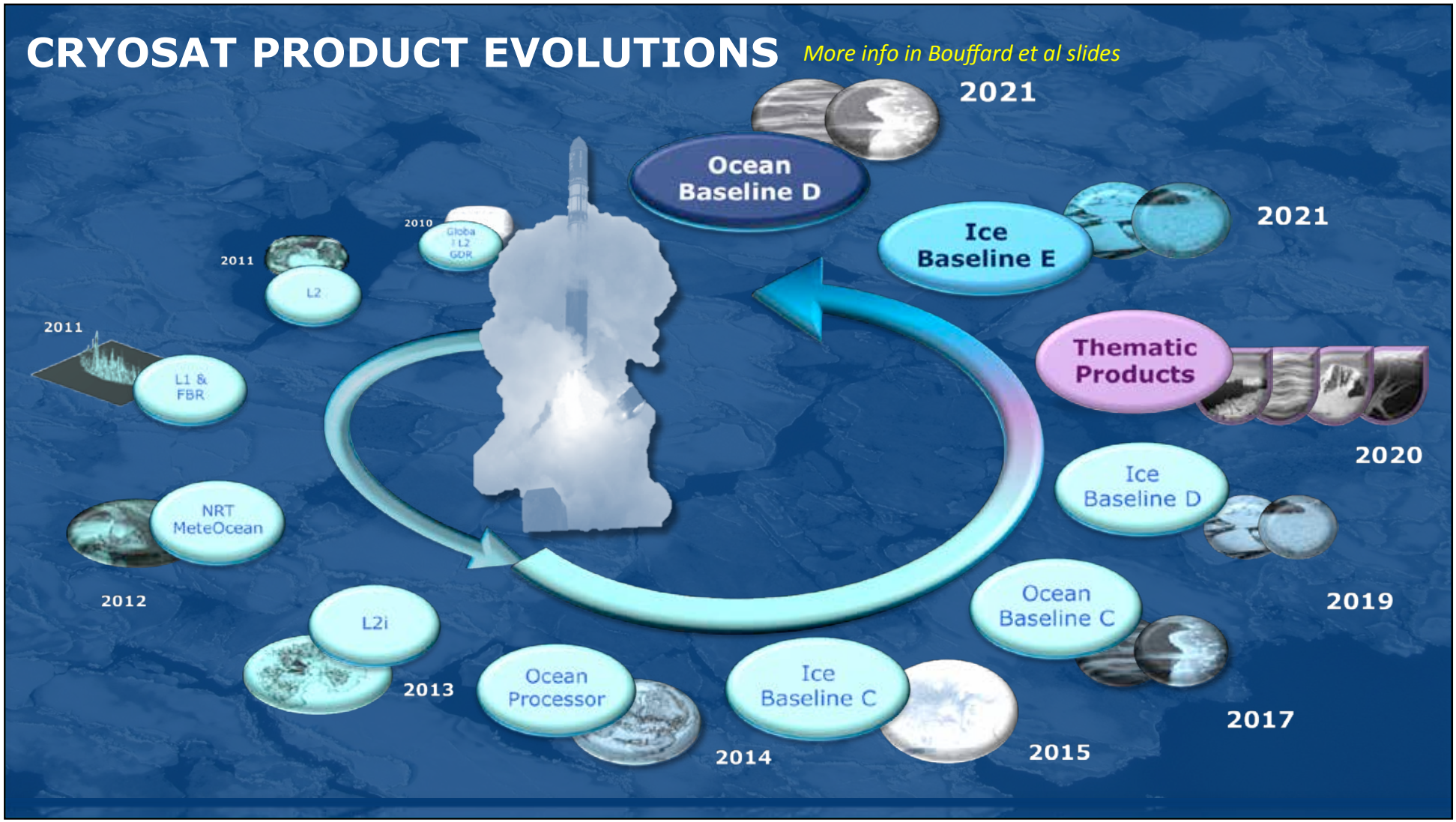


Observed and predicted sea level contribution due to Greenland Ice Sheet mass change according to different models compared to IMBIE latest results. CryoSat contribution was key to extend the data record to its lifetime.

The CS2-IC2 Resonant Orbits

- The orbit change called "19/20 nodal synch, aims at **synchronizing CryoSat-2 to ICESat-2 satellites**
- It offers a unique (and probably unrepeatable) possibility to have **coincident laser and radar altimeter** data over polar areas which are **key to understand climate change**
- It increases the duration of the footprint overlaps between the satellites and reduces the difference of observation time, particularly important for sea-ice with **no consequences on long-term climate data record**
- CryoSat-2 semi-major axis was raised by 900m between 16th and 31st of July 2020 with **no major issues**
- Next steps: dedicated calval campaigns to maximise scientific return, joint ESA/NASA sea-ice thickness product (TBC) and organise ESA-NASA workshop in 2022 to review the results from resonant orbits

Scientific Benefits: see backup slides


CRYOSAT PRODUCT EVOLUTIONS
More info in Bouffard et al slides
2021
Ocean Baseline D
2021
Ice Baseline E
2010
Globa l L2 GDR
2011
L2
2011
L1 & FBR
Thematic Products
2020
Ice Baseline D
NRT MeteOcean
2012
2019
Ocean Baseline C
L2i
2013
Ocean Processor
2014
Ice Baseline C
2015
2017

CRYOSAT PRODUCT EVOLUTIONS

More info in Bouffard et al slides

THE NEW PARADIGM OF "THEMATIC" PRODUCTS

Directly build on the **HERITAGE OF PREVIOUS R&D PROJECTS** in order to generate **OPERATIONALLY** CryoSat products in the areas of sea ice, polar oceans, land ice, coastal and hydrology.

State-of-the-art L2+ products including uncertainty parameters and fulfilling the need of **WIDE COMMUNITIES OF END-USERS** (e.g. modellers, Earth system scientists & operational services)

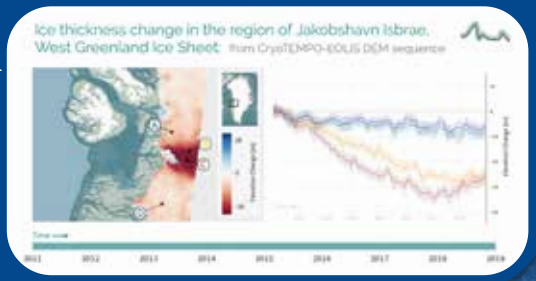
STATUS

CRYO-TEMPO "EOLIS" | prime: Earth-wave

Operational result of the R&D project CryoTop

New **Swath** point & gridded products

Over Greenland and Antarctica



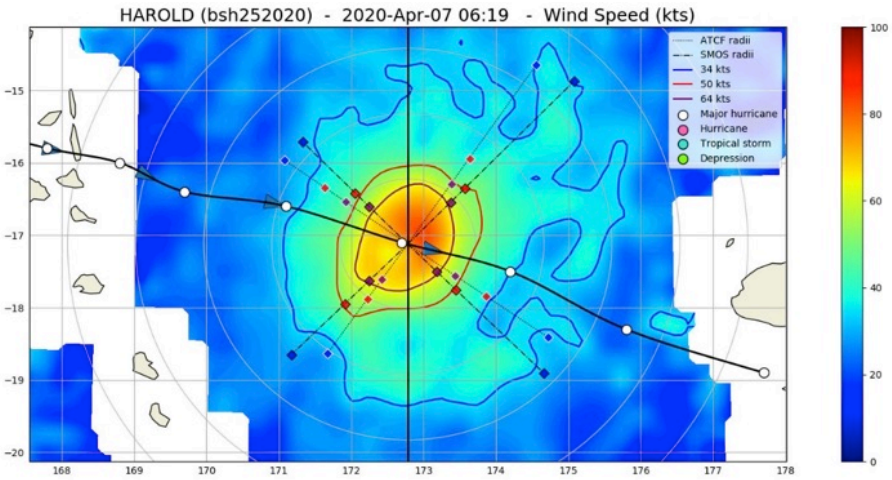
"OTHER" CRYO-TEMPO | prime: Lancaster Univ.

Project just KO on October 2020

Operational production planed on Q3 2021

Yearly evolution based on a Thematic User Group

SMOS Products: Severe wind speed



Sea surface wind speed as observed by SMOS over Cyclone Harold in South Pacific area between Vanuatu and Fiji. Wind speed radii at 34, 50 and 64 Kts are also shown. This wind radii information, provided from a SMOS dataset, is regularly provided to tropical cyclone national centres in order to better forecast cyclone structure and direction (Credit: IFREMER/ ODL/ESA).

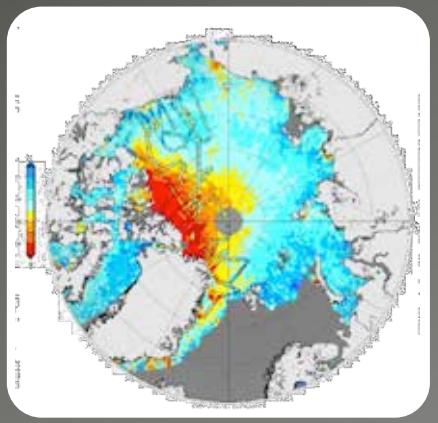
- ✓ Products operationally available since April 2020 in near real time (within 4-6 hours from acquisition) from IFREMER and ESA
  - https://www.smosstorm.org/
  - https://smos-diss.eo.esa.int/
- ✓ Products portfolio:
  - Level 2 retrieved surface wind speed with a spatial sampling of 1/4°x 1/4° in NetCDF-4 format
  - "wind radii fixes" 10-min maximum-sustained winds (in knots) and wind radii (in nautical miles) for the 34 kt (17 m/s), 50 kt (25 m/s), and 64 kt (33 m/s) winds per geographical storm quadrants in F-deck ATCF format
  - Level 3 daily composite maps of the collected Level 2
- ✓ Products validation: SMOS can measure winds up to 70-80 m/s with an accuracy of ~5 m/s. Wind radii uncertainties below best track uncertainties (i.e. no aircraft data)

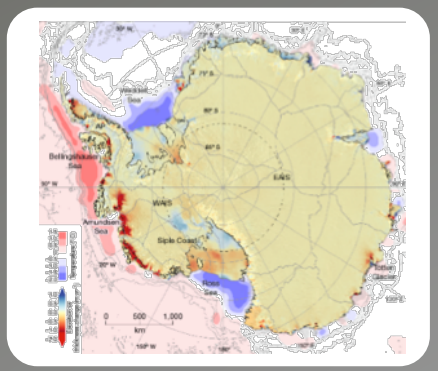
Copernicus Space Component-4 (CSC-4)

Copernicus polaR Ice and Snow Topography Altimeter Mission (CRISTAL)

Primary Monitoring & Measuring Goals

- Variability of Arctic and Southern Ocean **sea-ice thickness** and its snow depth
- Surface elevation and changes of **glaciers, ice caps** and the Antarctic and Greenland **ice sheets**





Secondary Goals

- Contribute to the observation of **global ocean topography as a continuum up to the polar seas**
- Support coastal and **inland water** applications
- Support **snow cover** and **permafrost** applications

Copernicus Space Component-4 (CSC-4)

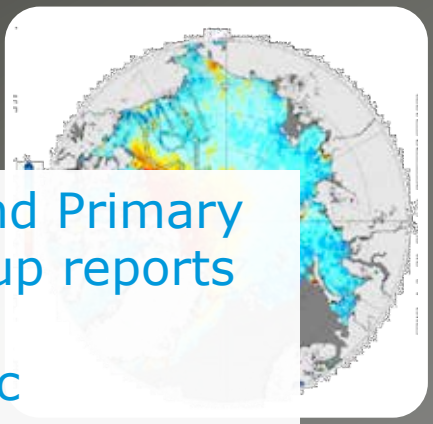
Copernicus polaR Ice and Snow Topography Altimeter Mission (CRISTAL)

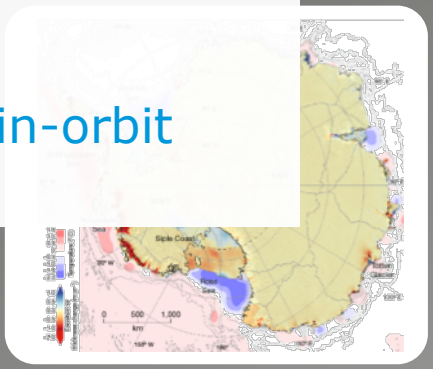
Primary Monitoring & Measuring Goals

- Variability of Arctic and Southern Ocean sea-ice thickness and its snow depth
- Surface elevation and changes of **glaciers**, **ice caps** and the Antarctic and Greenland **ice sheets**

Secondary Goals

- Contribute to the observation of **global ocean topography** as a **continuum up to the polar seas**
- Support coastal and **inland water** applications
- Support **snow cover** and **permafrost** applications



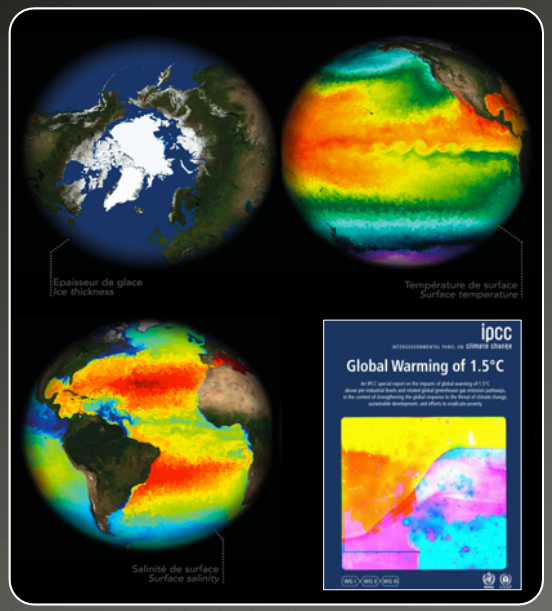


- ✓ CRISTAL directly addresses the EU Arctic Policy and Primary User Requirements expressed in Polar Expert Group reports
- ✓ CRISTAL responds to needs for continual altimetric monitoring of Arctic Ocean North of 81.5°N
- ✓ CRISTAL builds on heritage experience of several in-orbit missions

Copernicus Space Component-4 (CSC-4)

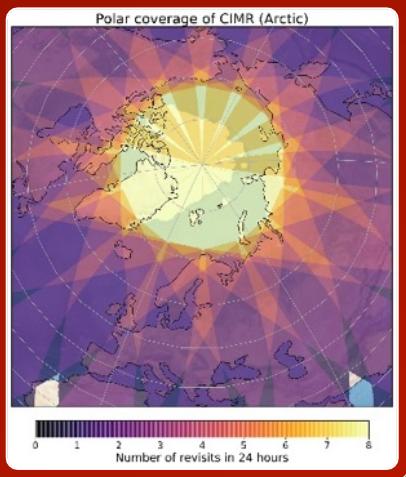
Copernicus Imaging Microwave Radiometer (CIMR)

Polar Oceans are fundamental to understanding the global environment



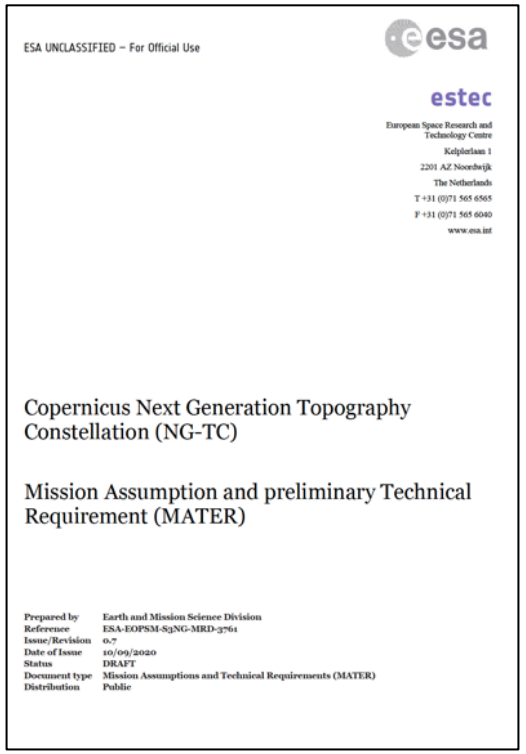
Sea Ice Concentration, Sea Surface Temperature, thin Sea Ice Thickness, Sea Surface Salinity, Wind Speed, Snow Water Equivalent, Soil Moisture

- Prevent data gap & be timely for an ice-free Arctic
- Measurements every ~6 hours in the Polar regions with 95% global daily coverage
- Data application in all Copernicus Services
- Directly addresses the EU Arctic Policy



Copernicus Next Generation Topography Constellation (NG-TC)

- Started preparations for the Next Generation Sentinel-3, Sentinel-6 and Polar altimeters as a Copernicus Topography Constellation
- Ad hoc Expert group convened and very active providing independent expertise to trace user needs to mission requirements. Representatives:
  - Scientists
  - Copernicus Services
  - ESA, EUMETSAT, CNES, EC
- A Mission Assumptions and Technical Requirements (MATR) document is in final stages of drafting
- A Concurrent Design Facility (CDF) activity (over 60 ESA Experts plus Industry support) in active sessions 2-3 times per week to develop concepts and solutions for the MATR.
- Activity is to check for feasibility and basic cost estimates
- Will conclude by end of 2020 output: MATR and CDF report
- a **SKIM/SWIM derivative design** (TRL=8 SRL=8, based on in orbit SWIM demonstrator) is currently being studied as part of the ESA Concurrent Design Facility Study for the NG-TC.


ESA UNCLASSIFIED – For Official Use

esa

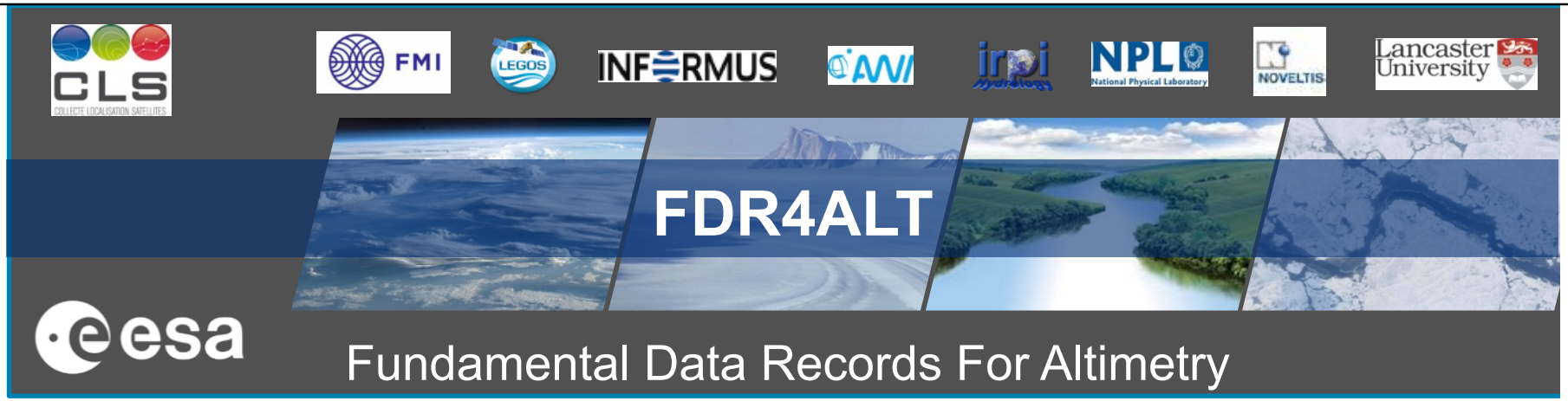
estec

European Space Research and Technology Centre
Keplerlaan 1
2201 AZ Noordwijk
The Netherlands
T +31 (0)71 565 6565
F +31 (0)71 565 6040
www.esa.int

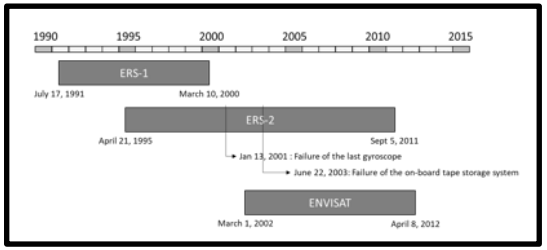
Copernicus Next Generation Topography Constellation (NG-TC)

Mission Assumption and preliminary Technical Requirement (MATER)

Prepared by	Earth and Mission Science Division
Reference	ESA-EOPSM-SgNG-MRD-3761
Issue/Revision	0.7
Date of Issue	10/09/2020
Status	DRAFT
Document type	Mission Assumptions and Technical Requirements (MATER)
Distribution	Public



- Study kicked off by ESA/ESRIN in Sept'19 with CLS as prime contractor + partners (3 years project)
- ESA **Long Term Data Preservation Programme** framework (LTDP+) aiming at generating innovative Earth system data records
  (**FDR** = Fundamental Data Records + **TDP** = Thematic Data Products)
- **ERS-1, ERS-2 and ENVISAT Altimeter & Radiometer reprocessing activity**, based on the best state-of-the-art algorithms/corrections with definition and provision of innovative level-1 and level-2P products



- Objective to serve with L2P products, the different communities involved in data exploitation of climate dataset over the different Earth surfaces : **ocean**, **coastal**, **inland water**, **ice sheets**, **sea ice** and **atmosphere**
- Strong synergies with past, current and future projects will be exploited: EMIR, FIDUCEO, REAPER, RA-2/V3.0, SL_CCI, SI_CCI, LI_CCI, SS_CCI, …

More about the Project : https://www.fdr4alt.org _Cf **FDR4ALT poster** @session from Tuesday to Thursday

EO4Society / FutureEO

On-going Projects

- World Ocean Circulation
- Coastlines
- HYDROCOASTAL
- Altimetry Virtual Lab (SARvatore Service to Users)
- and many more... See https://eo4society.esa.int

Future Projects

- Ocean Heat Content
- Eastern Boundary Upwelling Systems
- Next wave of Living Planet Fellowship

Future Flagship Actions in partnership with EC/DG-RTD

- Polar
- Ocean Health
- Biodiversity
- Coastal Hazards

CCI+ Sea Level, Sea State, Lake, Sea Level Budget Closure

SL_cci+: New Coastal Product issued. See Nature Scientific Data article: *Coastal sea level anomalies and associated trends from Jason satellite altimetry over 2002-2018* (2020), DOI: https://doi.org/10.1038/natureNNNNN (to be issued this week)

DOI of Elaborated Coastal Product: https://doi.org/10.17882/74354

DOI of Full Coastal Product: https://doi.org/10.5270/esa-sl_cci-xtrack_ales_sla-200206_201805-v1.1-202005

SS_cci+: The Sea State project is developing an 18-year data set (2002- 2020) capitalising on the rich satellite altimeter, SAR imager, and others. See publication: Dodet, G., et al..: *The Sea State CCI dataset v1: towards a sea state climate data record based on satellite observations*, Earth Syst. Sci. Data, 12, 1929–1951, https://doi.org/10.5194/essd-12-1929-2020, 2020.

Lake_cci+: develops satellite-derived products for the Lakes Essential Climate Variable, as defined by GCOS-200, Lake Water Level (LWL), Lake Water Extent (LWE), Lake Surface Water temperature (LSWT), Lake Ice Cover (LIC) and Lake Water-Leaving Reflectance (LWLR) – Lake Ice Thickness currently investigated

Merged satellite products accessible at: https://catalogue.ceda.ac.uk/uuid/3c324bb4ee394d0d876fe2e1db217378

Recent web stories based on Nature paper using Lake_cci+ data (https://doi.org/10.1038/s41558-020-0889-7) : https://www.esa.int/Applications/Observing_the_Earth/Space_for_our_climate/Global_lake_warming_trend_threatens_freshwater_species

SLBC_cci+: Extension of SLBC_cci to be launched as a competitive tender by December 2020.


esa GEWEX
16-18 NOVEMBER 2020 VIRTUAL EVENT
EO FOR WATER CYCLE SCIENCE 2020
ONLINE EVENT
The Conference is co-organized by ESA, GEWEX, EC (DG-RTD), UNESCO, CNES, CNRS/IPSL and the University of Versailles-Saint-Quentin
HYDROSPACE-GEOGloWS 2021
7-11 June 2021 | ESA-ESRIN | Frascati (Rome), Italy
esa
CryoSat 10th Anniversary Science Conference
14–17 June 2021 | Taormina, Italy
esa
Thank you for your attention!

ESA's Earth Observation Programmes

Backup Slides -- Slides for Replay

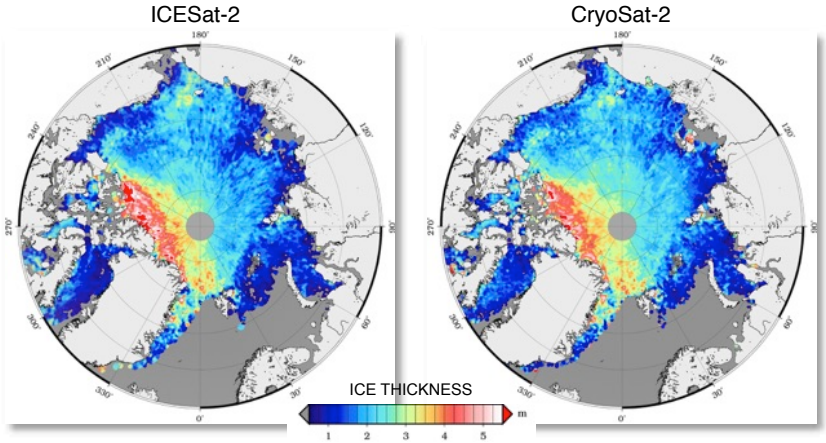
"Backup" slides not for showing in real-time... No time for questions...
... reference slides for viewing off-line in replay.

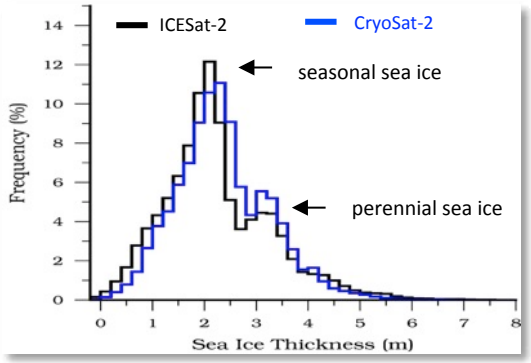
Jérôme Benveniste (Jerome.Benveniste@esa.int)
with contributions from many ESA colleagues:
Clément Albergel, Jérôme Bouffard, Craig Donlon, Mark Drinkwater, Pierre Féménias,
Michael Kern, Tommaso Parrinello, Marie-Hélène Rio et al.

Ocean Surface Topography Science Team Meeting (OSTST) 2020 Online, 19-23 October 2020

The CS2-IC2 Resonant Orbits: Scientific Benefits

- Derive snow depth, the largest source of uncertainty in retrieving sea ice thickness one of the most important **climate** indicators
- Understand the change in scattering horizons and different seasonal penetration seasonal on snow/ firn/ice with laser and radar signals
- Review the ice sheet mass balance records (IMBIE, CCI) and improve **climatology**
- Better characterization of SSB, DOT and SSH and improved understanding of polar ocean circulation and (sub)mesoscale dynamics at high latitude
- Correlate sea ice conditions with overhead cloud formation and understand links between lead in sea and cloud formation

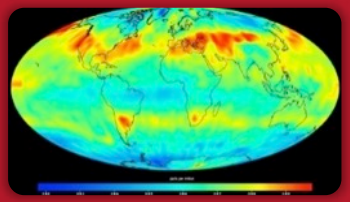


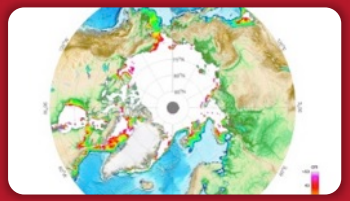


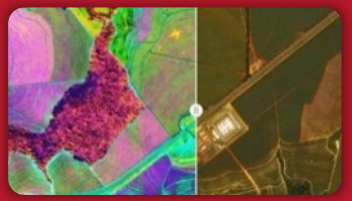
Copernicus Space Component-4 (CSC-4)

- New segment of existing programme; Space19+ is first of three phases
- 1402 M€ at 2019 e.c. (duration: 2020 – 2029)

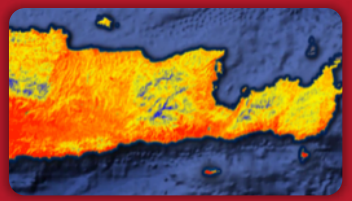
Phase B2/C/D/E1 of the six High Priority Candidate Missions

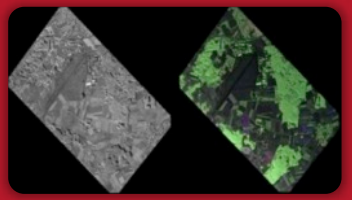

CO2M


CIMR


CHIME


CRISTAL


LST


ROSE-L

Ground Segment Development & Collaborative G/S activities

SMOS: OBJECTIVES & SCIENCE REQUIREMENTS

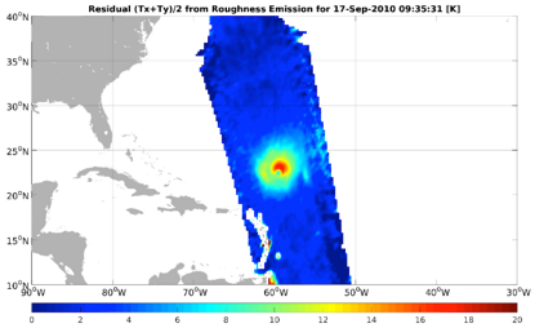
	Requirement	Status
Soil Moisture	4% volumetric soil moisture, spatial resolution 35-50 km, 1-3 days revisit time	Reached, based on an assessment of the data quality over representative validation sites.
Sea surface salinity	0.5-1.5 psu for single observation 0.1 psu for a 10-30 day average for a open ocean area of 200x200 km	Product accuracy over ocean is constantly improving and approaching targeted values, depending on regions.
Sea ice thickness	Daily sea ice thickness estimates based on MIRAS observations shall be provided for the Northern Hemisphere with a spatial resolution of 10.000 km^2 up to maximum values of 50 cm.	Reached.
Water cycle processes	SMOS observations shall be analysed with respect to geophysical processes related to the water cycle occurring on time scales exceeding the mission lifetime of 3 (5) years.	On-going scientific work.

Measurement principle: MIRAS (Microwave Imaging Radiometer using Aperture Synthesis instrument): **passive** microwave 2-D interferometric radiometer measuring in L-Band (1.4GHz, 21cm)
Orbit: altitude of 758 km; inclination of 98.44°; low-Earth orbit, polar, sun-synchronous.

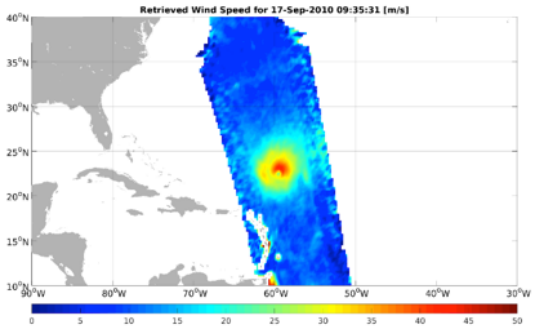
SMOS Severe winds – new operational product

Product available in near-real time from end 2018 from IFREMER/ODL and ESA

Tag name	Description
wind_speed (time,lat,lon)	Gridded swath of Sea surface wind speed from SMOS
wind_speed_error (time,lat,lon)	Uncertainty of the Sea surface wind speed from SMOS
time (time,lat,lon)	UTC time at each pixel
lon(lon)	Longitude of the gridded SMOS wind speed data
lat(lat)	Latitude of the gridded SMOS wind speed data
cross_track_distance (time,lat,lon)	Across track distance at each node expressed in the xi coordinate of the director cosine of SMOS antenna plane
quality_level (time,lat,lon)	Quality level associated with the pixel measurements
rejection_flags (time,lat,lon)	processing flags



SMOS brightness temperature excess

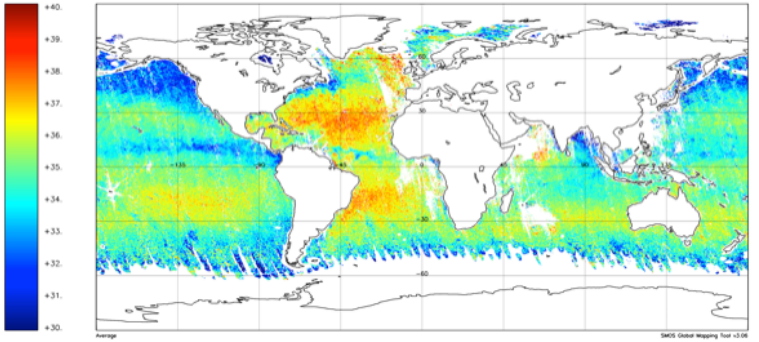


Retrieved SMOS wind speed

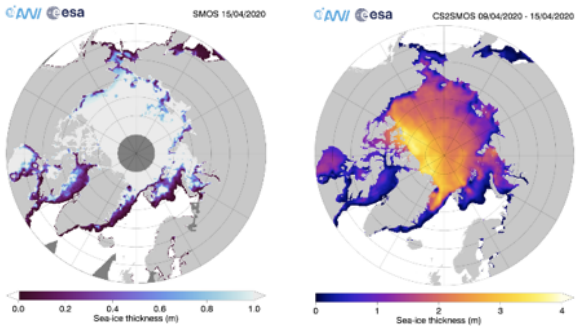
Additional SMOS Products over Ocean from ESA

- ✓ Products operationally available since beginning of mission from ESA
  - https://smos-diss.eo.esa.int/

- ✓ Products portfolio:
  - Level 2 retrieved sea surface salinity on ISEA4H9 grid in NetCDF-CF format
  - Level 3 daily map of retrieved sea-ice thickness on polar stereographic grid (sampling 12.5 km) up to a depth of 0.5-1 m. North Hemisphere from October to April.
  - Level 4 combined SMOS Cryosat-2 daily map of retrieved sea-ice thickness on polar stereographic grid (sampling 12.5 km). North Hemisphere from October to April.



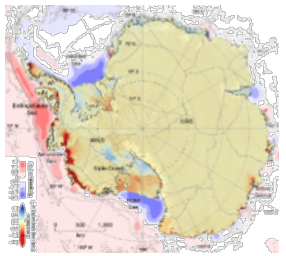
Sea surface salinity weekly map derived from SMOS ascending orbit direction observations (Credit: ESA).



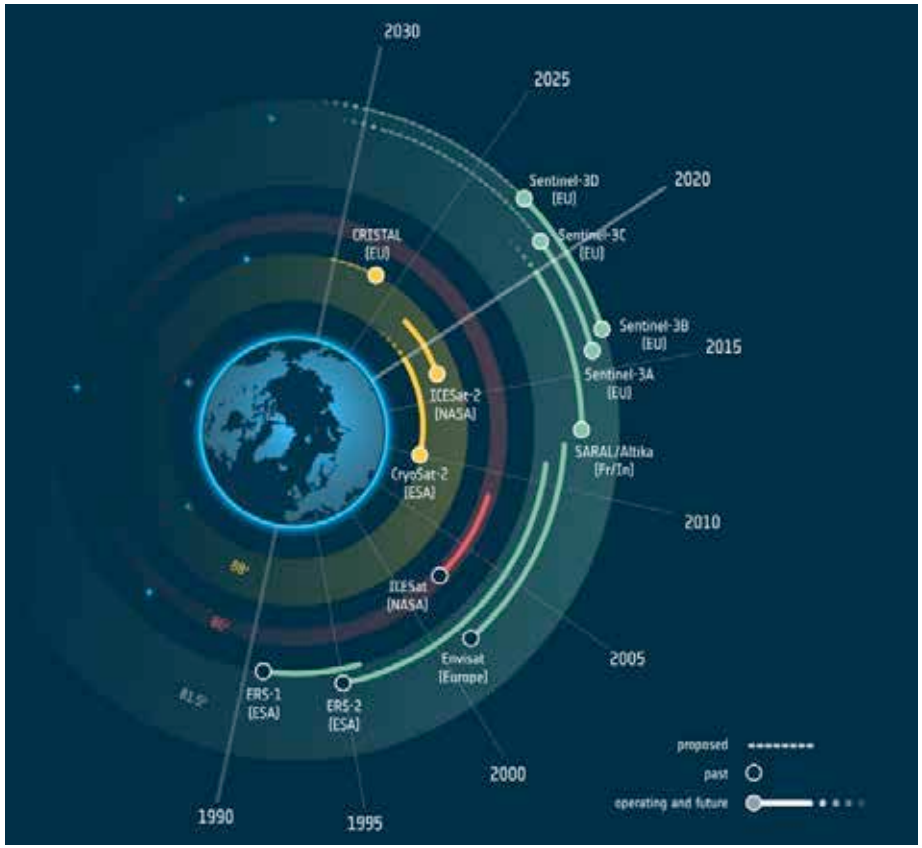
Sea ice thickness daily map derived from SMOS (left panel) and combined SMOS Cryosat-2 (right panel) observations (Credit: AWI/ESA).

CRISTAL Key Mission & Performance Requirements

- **SAR Interferometric Altimeter** for global elevation & topographic retrievals over land and marine ice, ocean and terrestrial surfaces.
- Additional **Ka-band channel** for snow depth measurement to distinguish between snow and ice layer.
- **Vertical resolution of ~31cm** with enhanced freeboard measurement accuracy compared to today.
- **Very high along-track resolution** to resolve ice floes and leads.
- **Operation modes optimised**: SAR closed burst operation over open and coastal ocean; interleaved mode over sea ice and iceberg regions.
- Improved interferometric measurements (angle of arrival) **20 arcsec.**
- **Microwave Radiometer for** wet trop delay corrections and surface-type classification.
- **High data volume** due to SAR mode to be downlinked.
- **Product latencies** range from 3 hours (for ocean L2 products), 6 hours (sea ice freeboard products), 24 hours, 48 hours up to 30 days (surface elevation).



CRISTAL is an essential part of the Topographic Ocean and Ice measurement family



- **Ku-band Interferometric Synthetic Aperture Radar Altimeter** with supporting **Ka-band channel**
- Passive microwave **radiometer** (wet troposphere correction)
- 7.5 years design lifetime
- Optimized orbit configuration **covering polar regions**
- **High along-track resolution** and different operation modes
- Product **latencies** from **NRT to 30 days** depending on application.
- Launch mid 2020-2030
- OSTST 2019 recommends Agencies to strive to launch a high-resolution polar altimeter in the early 2020s (such as the proposed HPCM CRISTAL) and to maintain operation of CryoSat-2, ICESat-2, and SARAL/AltiKa as long as possible.

Status:

The CRISTAL HPCM mission Phase B2/C/D/E1 Tender Evaluation process is in progress and preparations for the IPC meeting in June 2020 are underway.

Copernicus Services supported: C3S, CMEMS, CLMS, CAMS, CEMS

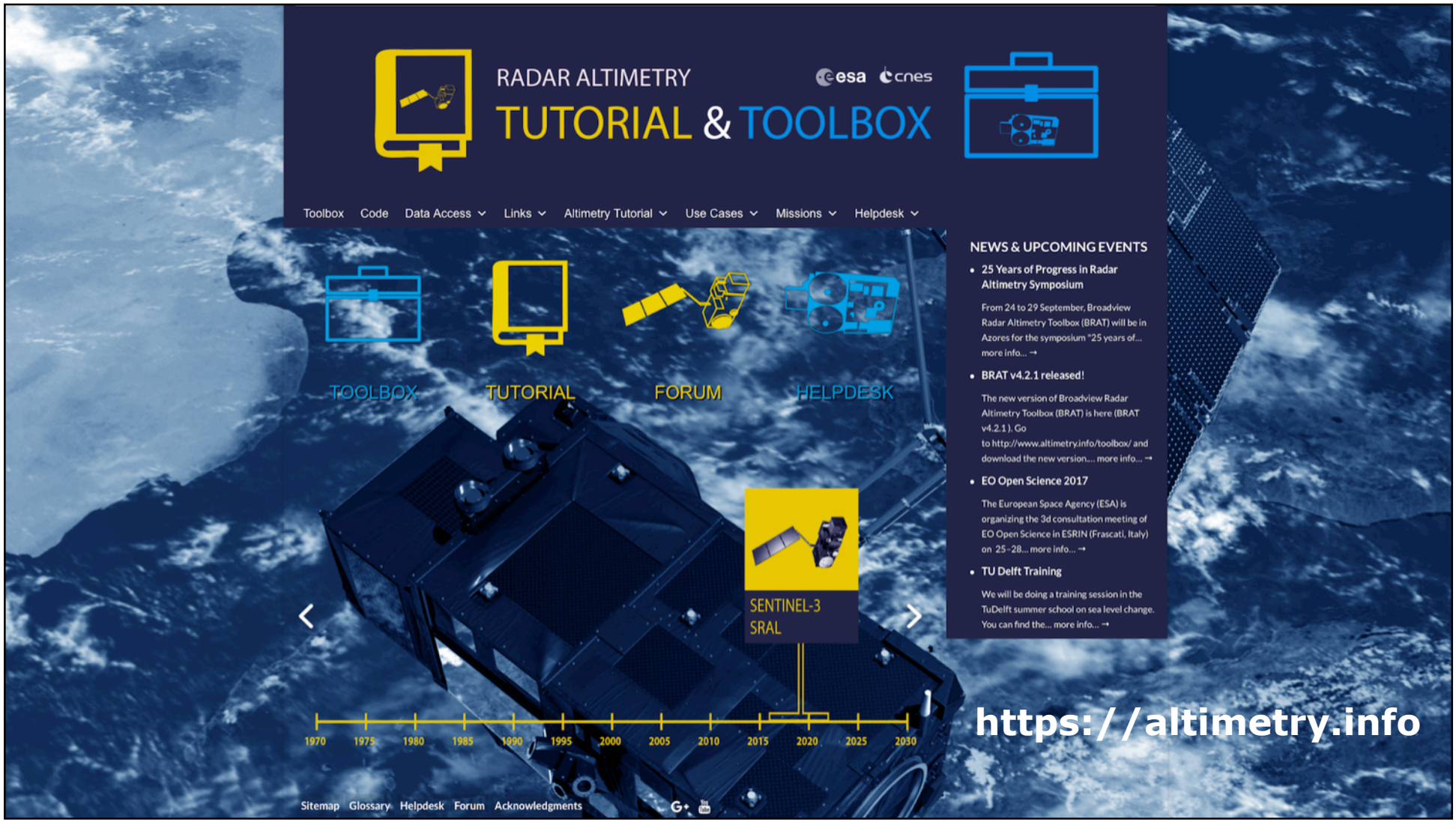
The G-POD Sentinel-3 & CryoSat-2 SAR/SARin Processing Service

The G-POD Sentinel-3 & CryoSat SAR/SARin Processing service, coined **SARvatore**, is a web platform that provides the capability to process on line and on demand **User-customised Sentinel-3 SAR and CryoSat SAR and SARin data, from L1a (FBR) data products until SAR/ SARin Level-2 geophysical data products,** over any surface with alternate retrackers (e.g. **SAMOSA+**). The service is **open, free of charge and accessible on line from everywhere**.

The Service has fostered more than **Twenty-five peer-reviewed publications** and 2 PhD theses in its 5 years of existence. The GPOD/ SARvatore service has **202 Users** supported with: 3150033 CPU hours (that's **360 CPU years**), 71938 processing tasks completed (since the beginning) and **929.60 TB processed** (since the beginning).

New **SAMOSA++** and **FF-SAR** processors will soon be opened to the public.

https://gpod.eo.esa.int/services/CRYOSAT_SAR
https://gpod.eo.esa.int/services/CRYOSAT_SARIN
https://gpod.eo.esa.int/services/SENTINEL3_SAR


RADAR ALTIMETRY
TUTORIAL & TOOLBOX
esa cnes
Toolbox Code Data Access Links Altimetry Tutorial Use Cases Missions Helpdesk
TOOLBOX
TUTORIAL
FORUM
HELPDESK
SENTINEL-3
SRAL
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030
Sitemap Glossary Helpdesk Forum Acknowledgments
NEWS & UPCOMING EVENTS
25 Years of Progress in Radar Altimetry Symposium
From 24 to 29 September, Broadview Radar Altimetry Toolbox (BRAT) will be in Azores for the symposium "25 years of... more info... →
BRAT v4.2.1 released!
The new version of Broadview Radar Altimetry Toolbox (BRAT) is here (BRAT v4.2.1). Go to http://www.altimetry.info/toolbox/ and download the new version.... more info... →
EO Open Science 2017
The European Space Agency (ESA) is organizing the 3d consultation meeting of EO Open Science in ESRIN (Frascati, Italy) on 25-28... more info... →
TU Delft Training
We will be doing a training session in the TuDelft summer school on sea level change. You can find the... more info... →
https://altimetry.info

Baltic+ SEAL

Main objectives

- Create and validate an improved SEA Level data product for the Baltic Sea.
- Combine the latest innovations in Coastal Altimetry and data processing, with regional expertise and knowledge of our Baltic Sea environment.
- Provide an advanced sea-level information product to Baltic Sea stakeholders, and improve the performances of the current ESA Sea Level Climate Change Initiative.

Project Achievements (at the time of MTR)

- Unsupervised Classifier & Advanced ALES+ SAR Retracker developed.
- Multi-mission calibration performed. First validation analyses presented.
- Internal Datasets generated and evaluated (along-track data).
- Results of the User Requirements Survey presented.

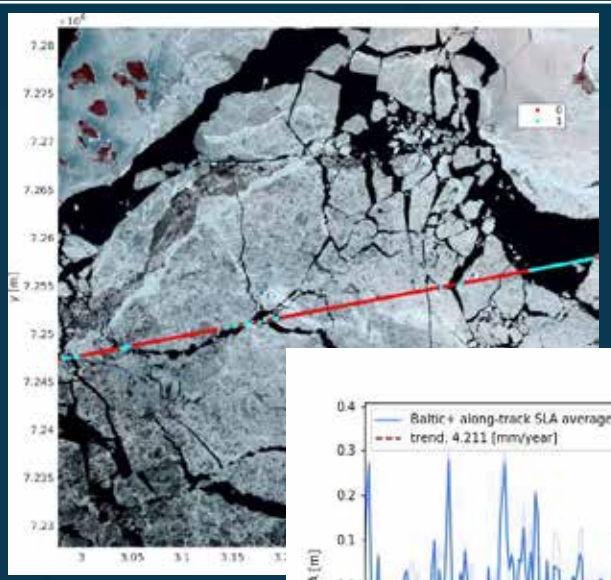
KO: 29/04/19

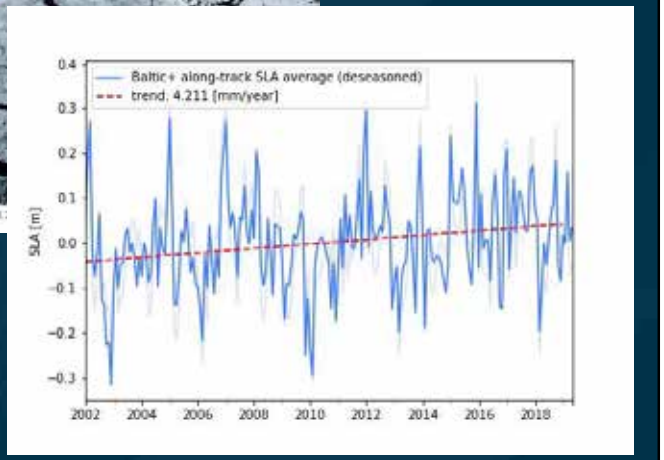
Duration: 18 months

Baltic+ SEAL

Outlook

- Start the remaining WPs (Datasets generation & Impact assessment, Scientific Roadmap).
- Production of updated internal datasets.
- Establish the Baltic+ SEAL suite of products for different users.
- Evaluate the uncertainty & characterize the error.
- Produce gridded data possibly allowing to capture short-term events (*"silent storm surge"*).
- Validate and publish the Baltic+ SEAL datasets.





Project website: http://balticseal.eu/

HYDROCOASTAL (Radar Altimetry for COASTAL ZONE and INLAND WATER)

Main objectives

- Exploitation of the Synthetic Aperture (**SAR**) mode measurements of **CryoSat-2, Sentinel-3A and Sentinel-3B**, and Synthetic Aperture Interferometric (**SARin**) mode measurements of CryoSat-2 in the coastal and inland water domains, for the **UN Sustainable Development Goals number 6, Water**, and the societal benefit of a better understanding of **interaction processes between River Discharge and the Coastal Zone Sea Level**.

Key Objectives

- Enhancing the capability of characterising and understanding **small-scale coastal processes**
- Enhancing the capability of characterising and understanding **cross-shelf processes and interactions between the open-ocean and continental shelf dynamics**.
- Enhancing the capability of characterising and understanding the **multi-scale variation of inland water storage**, fluxes and exchanges with the ocean (from inter-annual to sub-seasonal) and **their long-term impact on regional sea-level changes.**

KO: 25/02/2020

Duration: 2 years

HYDROCOASTAL (Radar Altimetry for COASTAL ZONE and INLAND WATER)

Output

All activities are expected to drive and support the development of future missions, suggesting systems, processing baselines and supporting the adoption of a specific orbit (repeating vs. non-repeating).

Datasets

- Global validated Coastal Zone data set built from SARin and SAR mode.
- Global validated River Discharge data set for large to medium rivers.
- Experimental dataset for small rivers and tributaries.

A Future Roadmap shall be delivered.

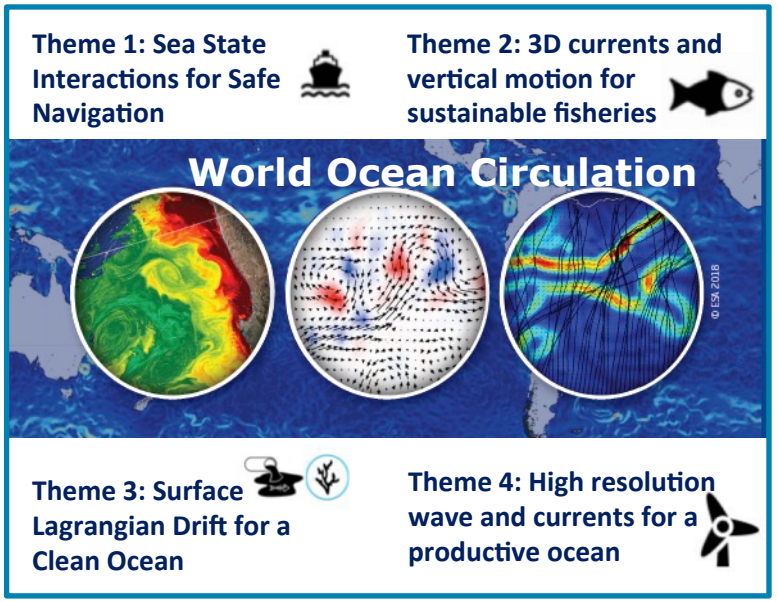
Project website: https://www.satoc.eu/projects/hydrocoastal/

The World Ocean Circulation Project

Context: Ocean circulation, especially in its first few hundred meters, is a key variable needed by a wide range of users (Maritime Safety, marine pollution, Renewable Marine Energy industries, Fisheries and Aquaculture, or maritime transport sectors…). Most users require better than 10km/1 day effective spatio-temporal resolution products of the upper-layer circulation, which is far for being achieved at global scale with the current observing capability.

The WOC project
was kicked-off on June,10th for a 2 year duration
Project led by **ODL with CLS, IFREMER, NERSC, ICM-CSIC, Ocean-Next, CNR, Utrecht University as sub-contractors.**

Objective: Develop and validate innovative methods allowing to optimize the synergetic capacity offered by satellite data, in situ measurements and numerical models for **improving the retrieval of the upper-layer ocean circulation** over FOUR pilot areas , in conjunction with committed end-user organizations



The Cyclone Monitoring Service with Sentinel-1 (CYMS) project

Context: Several studies (Mouch et al, 2017, 2019) have demonstrated the capability of combining the VV and VH channels as measured by SAR allows to provide Ocean Surface Wind measurements from space

- at high resolution
- in open oceans and coastal areas
- Over extreme hurricanes

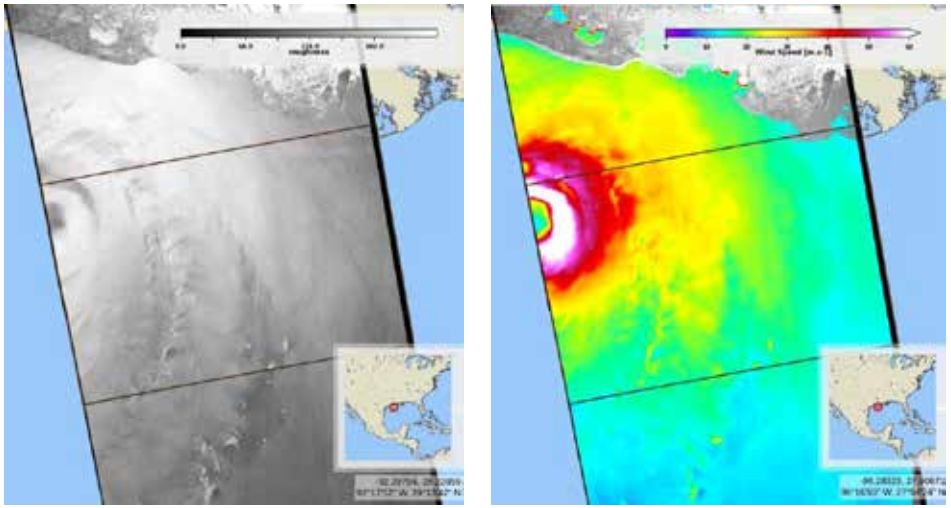
The CYMS project

ESA open call started in January 2020 (1 year duration)
Project led by **CLS with IFREMER** as sub-contractor

Objective: scale up the S-1 operational capability in view of its potential integration as part of a Copernicus Service.

The service would include not only NRT consistent, standardized, interoperable operational wind field products harmonized across international institutions and bodies but also an archive centre ensuring a continual improvement cycle and full data uptake by stakeholders.

*S1-A acquisition showing **Laura at Category 4** few hours before landfall in Louisiana, on 2020/08/27 00:09 UTC.*



Winds (right) computed from roughness (left).

Satellite Hurricane Observation Campaign (SHOC 2020) is currently on-going in the frame of this project

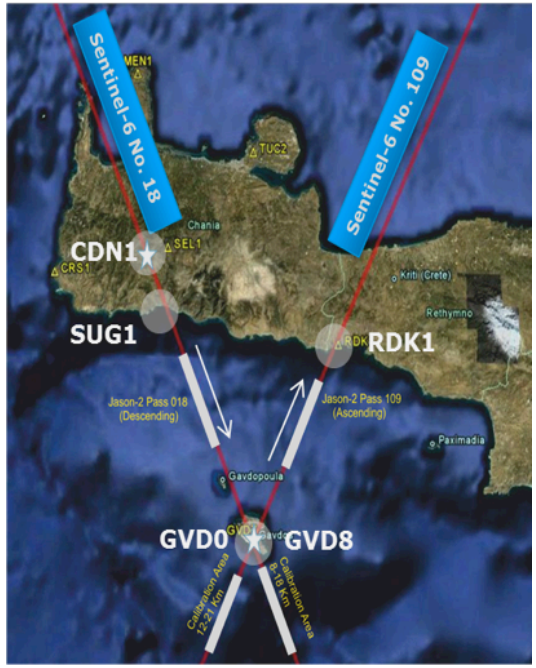
FRM4S6 Fiducial Reference Measurements for Sentinel-6

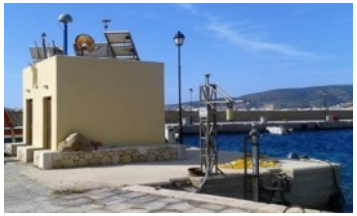
Summary

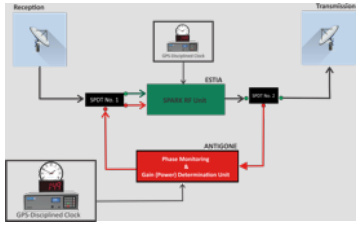
- Application of the Permanent Facility for Altimeter Calibration and validation (PFAC) Crete, Greece in support of Sentinel-6
- Includes CDN-1 transponder, operation, maintainence and data overpass processing
- Includes development of a new transponder for range and Sigma-0 to be located on Gavdos Island

Status:

- CD-1 ready for S6 Operations (see https://www.frm4s6.eu/)
- GVD-1 in development – operations in early 2021
- Discussions to install DORIS beacon
- ESA Contact: craig.donlon@esa.int







S6-JTEX: S6-MF & Jason3 Tandem flight Exploitation

- **New Activity (Open competition ITT, Q4 2020)**
- Aim: ***Demonstrate the capability of Sentinel-6MF data through scientific exploitation of the mission during tandem and nominal orbit operations***
  - Assemble Data set S6-MF, J3, S3A+B and others to conduct a scientific assessment of S6-MF
  - Identify, characterise, confirm and conduct scientific analyses to mitigate discrepancies between S6-MF, Jason-3 and investigate their origin to reduce uncertainties
  - Develop innovative scientific studies that exploit the capabilities offered by S6-MF for new potential products and applications
  - Prepare and submit ten Scientific Journal articles reporting the results of the S6-JTEX study