



CFOSAT: 2nd International Science Team Meeting 15-18 March 2021

SWIM & FROGS Status

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Agenda



❖ SWIM Status

- Instrument status
- CAL/VAL status

❖ FROGS Status

- Processing chains status
- System availability performances
- Production performances
- SWIM reprocessing
- Products access & distribution
- IWWOC





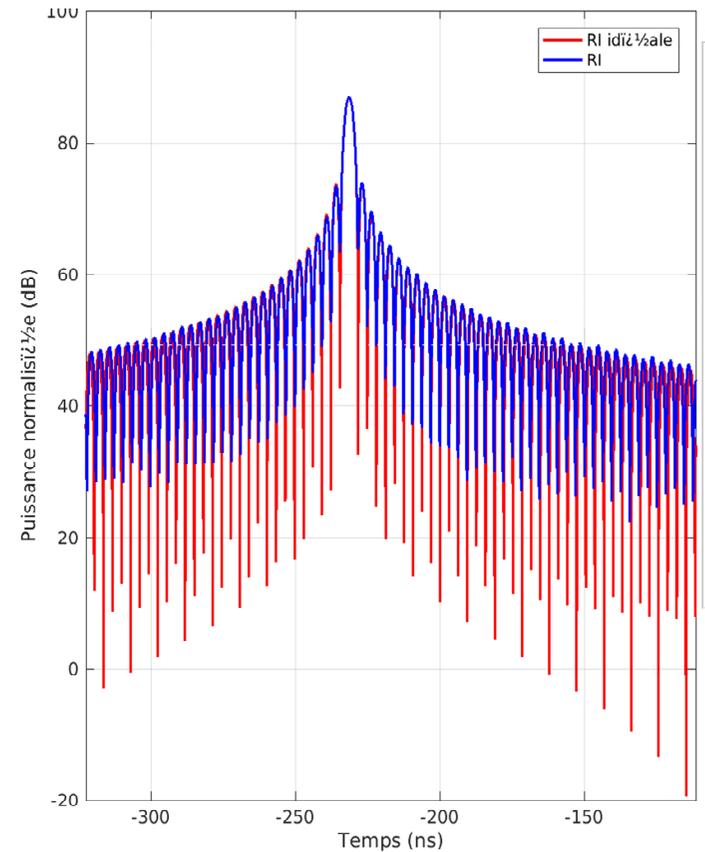
SWIM STATUS

SWIM Instrument Status



SWIM Functional and Performances validation

| SWIM FONCTIONNAL VALIDATION | WITHIN REQUIREMENTS? | STABLE IN TIME? |
|-----------------------------|----------------------|-----------------|
| Impulse response | ✓ | ✓ |
| Power/current consumption | ✓ | ✓ |
| Temperature | ✓ | ✓ |
| Coverage in tracking mode | ✓ | ✓ |
| Antenna rotation speed | ✓ | ✓ |



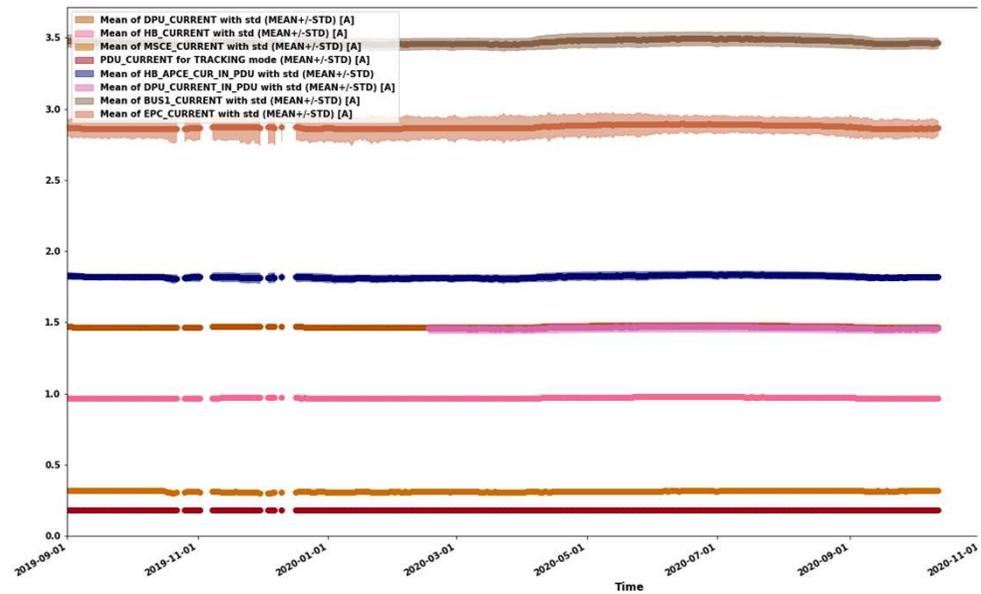
SWIM Instrument Status



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| Temperature | ✓ | ✓ |
| Coverage in tracking mode | ✓ | ✓ |
| Antenna rotation speed | ✓ | ✓ |

Very stable current consumption since beginning of life

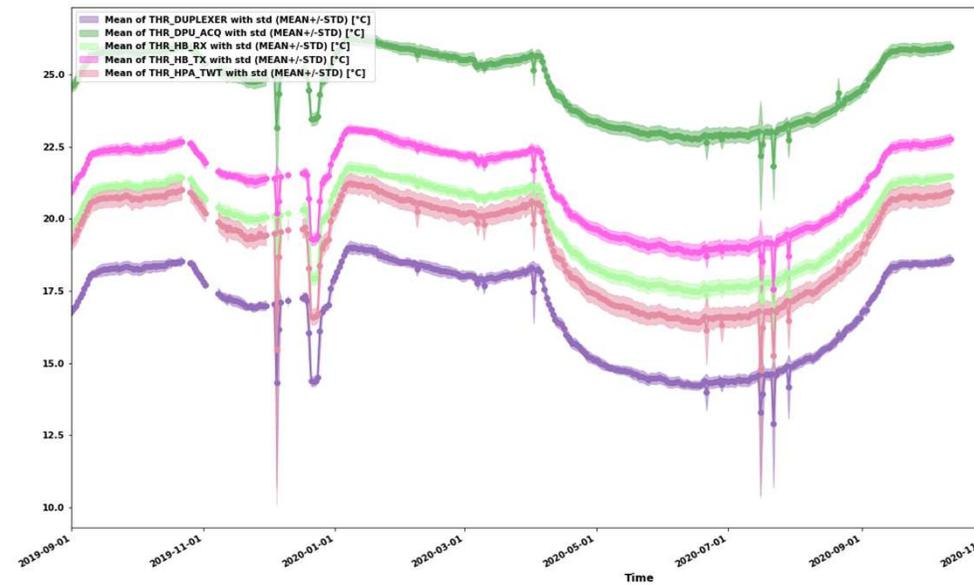


SWIM Instrument Status

SWIM Functional and Performances validation

| SWIM FONCTIONNAL VALIDATION | WITHIN REQUIREMENTS? | STABLE IN TIME? |
|-----------------------------|----------------------|-----------------|
| Impulse response | ✓ | ✓ |
| Power/current consumption | ✓ | ✓ |
| Temperature | ✓ | ✓ |
| Coverage in tracking mode | ✓ | ✓ |
| Antenna rotation speed | ✓ | ✓ |

Very stable temperature since beginning of life
variation $\pm 4^{\circ}\text{C}$

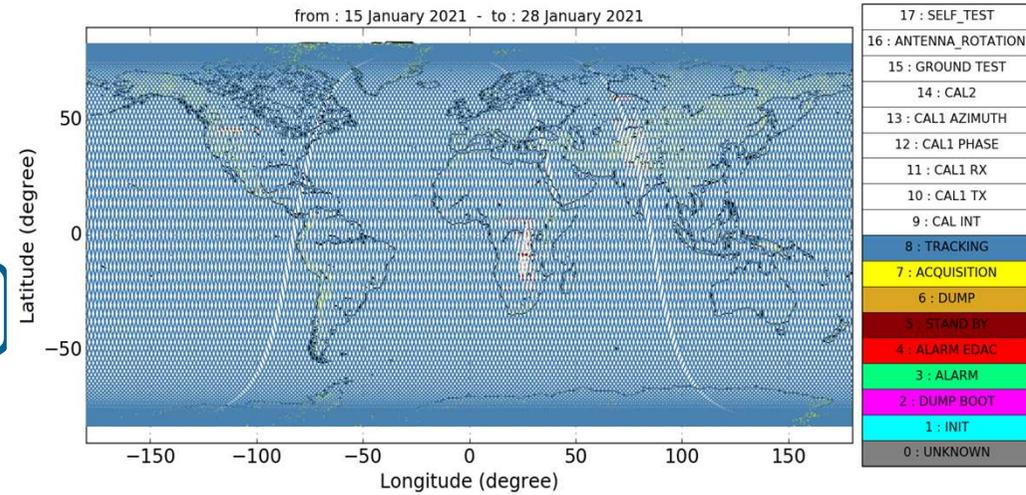


SWIM Instrument Status

SWIM Functional and Performances validation

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| Impulse response | ✓ | ✓ |
| Power/current consumption | ✓ | ✓ |
| Temperature | ✓ | ✓ |
| Coverage in tracking mode | ✓ | ✓ |
| Antenna rotation speed | ✓ | ✓ |

Very good signal acquisition in TRACKING mode over ocean, land, ice and sea ice



SWIM Instrument Status

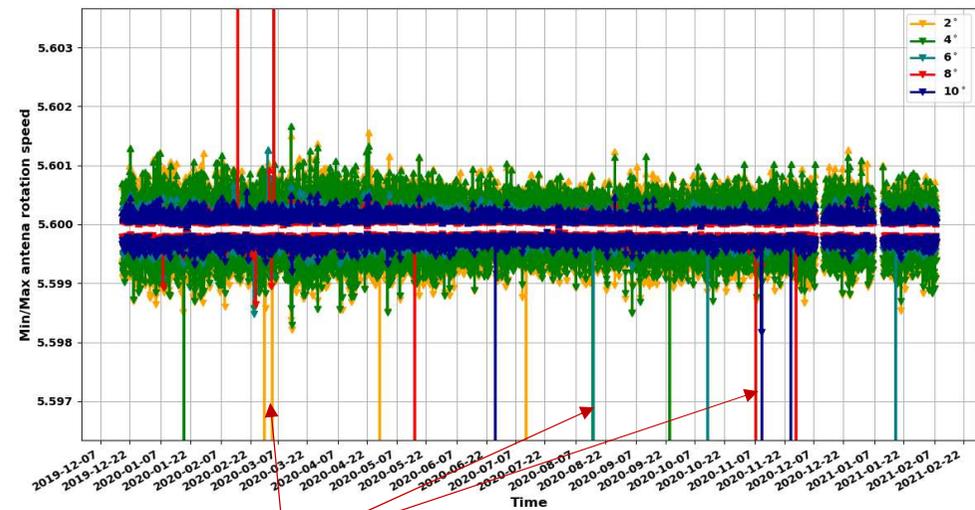


SWIM Functional and Performances validation

| SWIM FONCTIONNAL VALIDATION | WITHIN REQUIREMENTS? | STABLE IN TIME? |
|-----------------------------|----------------------|-----------------|
| Impulse response | ✓ | ✓ |
| Power/current consumption | ✓ | ✓ |
| Temperature | ✓ | ✓ |
| Coverage in tracking mode | ✓ | ✓ |
| Antenna rotation speed | ✓ | ✓ |

Compliant with requirements

Minimum and maximum of antenna rotation speed by beam from 2019/10/01



Algorithm spurious



SWIM Instrument Main Events



Operational event:

Mission unavailability of 5 days in January 2021 :

- ❖ From 2021/01/06, 12h26 to 2021/01/11,12h10 UT

- ❖ Unexpected transition of SWIM Instrument to ALARM mode and then to INIT with the antenna stop
 - Problem identified: impact of a single event upset (SEU/SET) on the on board communication system
 - **no risks on instrument electronics**

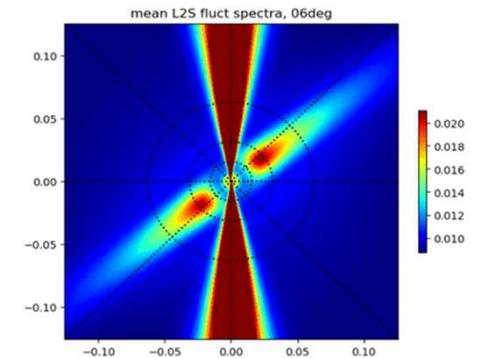
- ❖ Quick return to nominal SWIM instrument processing
 - Thanks to NSOAS and DFH reactivity and collaboration



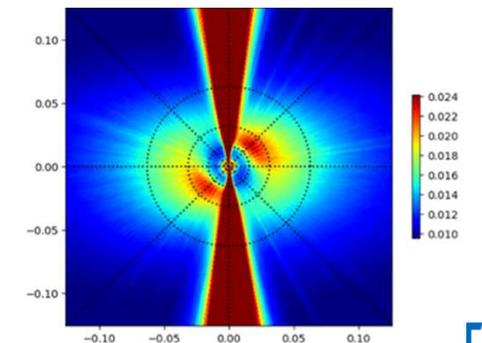
On-board migration correction (reminder):

- ❖ The CAL/VAL analysis of L2 SWIM data had evidenced one major problem
 - useful information related to ocean waves was filtered out
 - => waves at $\pm 45^\circ$ from along-track direction were the only detected in the directional wave spectra obtained from each spectral beams ($6^\circ, 8^\circ, 10^\circ$)
- ❖ Anomaly identified :
 - At the real-time on-board processing level,
 - An on-board parameter for the migration compensation (applied to spectral beams only) was incorrectly implemented
- ❖ Anomaly corrected since 2019, April the 25th
 - This parameter was corrected on-board successfully
 - No more filtering in the directional wave spectra obtained at each spectral beams
 - SWIM products delivered to user nominally since that date.

Mean fluctuation spectra for the 6° incidence beam

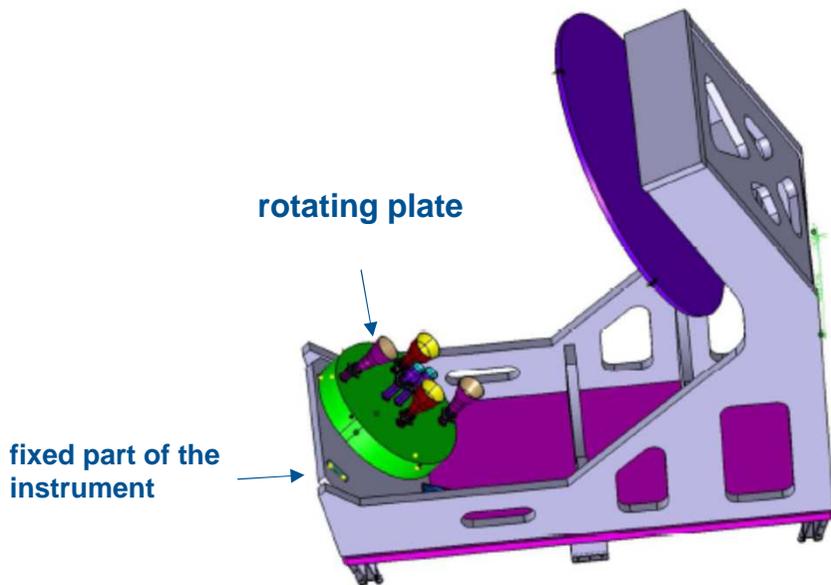


After correction of the on-board migration compensation



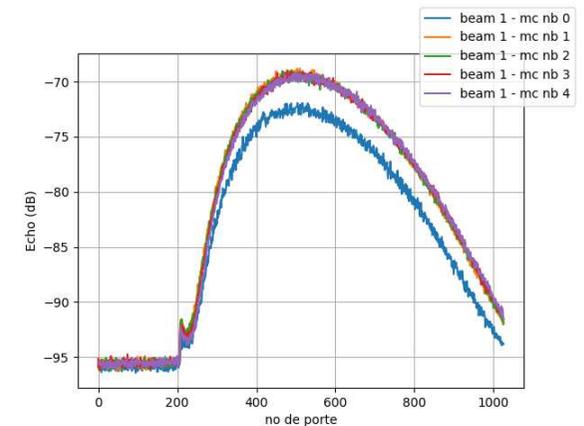
Micro-cuts anomaly in antenna sub-systems:

- ❖ Signal transmission behavior: anomaly on antenna signals
 - So called RMA anomaly observed since end December 2018:
 - scarce micro-cuts in the signal transmission between rotating plate and fixed part of the instrument



Impact on sigma0 products:

- ❖ tracking signal loss due to micro-cuts
 - loss of pulses within an echo
 - decrease of sigma0



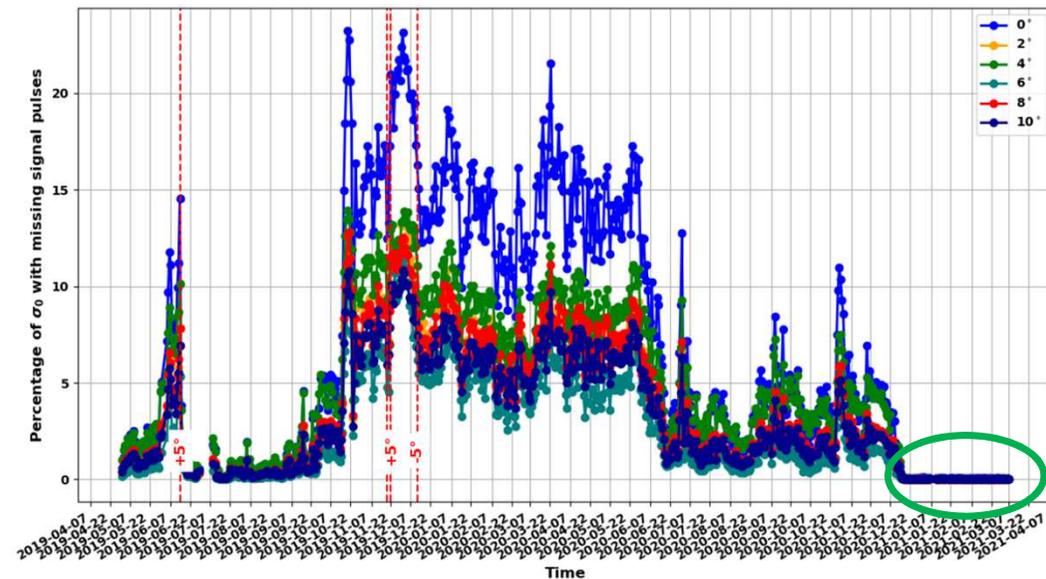
Example of sigma0 decrease for beam 2° over four consecutive macrocycles (2019/04/17, 17h44)

SWIM Instrument Main Events

Micro-cuts anomaly in antenna sub-systems:

- ❖ Cause :
 - Pollution or outgazing suspected
- ❖ Micro-cuts impact monitoring
 - Phenomenon monitored daily
 - No major impact on SWIM products
 - Dedicated flag (L1a) implemented in products
 - Very few occurrences since December 2020

Rate of micro-cuts impact on sigma0 profiles during tracking mode from 01/05/2019 to 08/03/2021



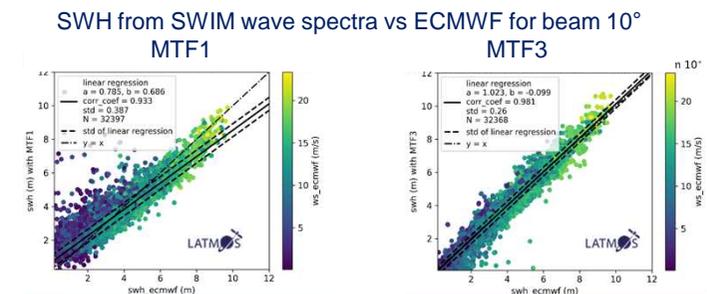
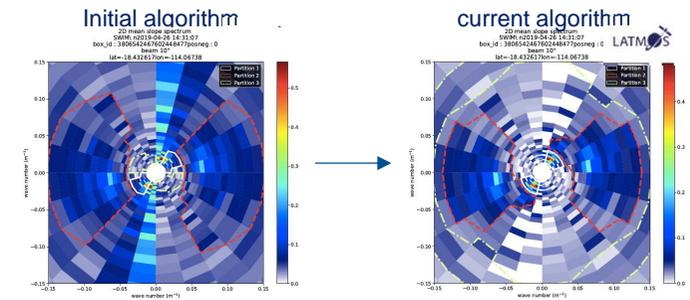
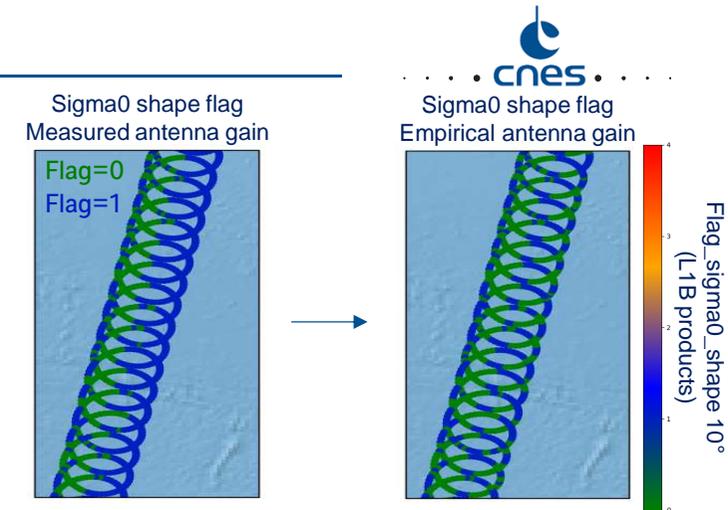
SWIM CAL/VAL Status

Main evolutions in the latest product issue

- ❖ Antenna gain diagram adjustment
 - First issue of empirical gain diagram
 - Partially corrects azimuthal asymmetry in sigma0 profiles

- ❖ Speckle correction:
 - New speckle correction algorithm accounting for observed dependencies with latitude and sea-state
 - No more masking of the $\pm 15^\circ$ sector in the wave spectra

- ❖ Modulation Transfer Function selection (MTF):
 - Algorithm used to transform the modulation spectra into wave slope spectra
 - Selection of a the so called MTF3
 - Use of the significant wave height from nadir beam to normalize spectrum energy
 - Correct bias observed on wave height parameter



SWIM CAL/VAL Status



Current CFOSAT SWIM products quality

❖ Nadir data

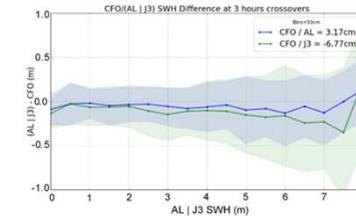
- SWH :
 - Compared to model : around 30cm
 - same performance than altimetry missions (Jason 3, AltiKa, HY2A...)
- Wind speed :
 - Compared to model : around 1m/s

❖ Sigma0 profiles:

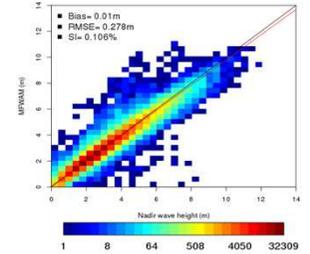
- Ocean surface :
 - Trends consistent with TRMM/GPM
 - Consistency better than 1dB => compliant with requirement
 - Similar Inter beams bias identified by French and Chinese teams
 - => Will be applied soon in the processing
- Sea ice and land surface
 - good sensitivity and consistent with literature

❖ 1D Wave spectra

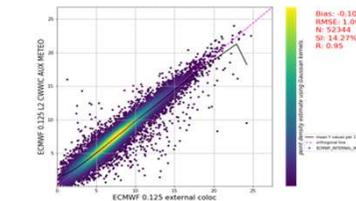
- Shape consistent with model and buoy data
- Good wavelength estimation
- Some parasite peaks to be filtered out



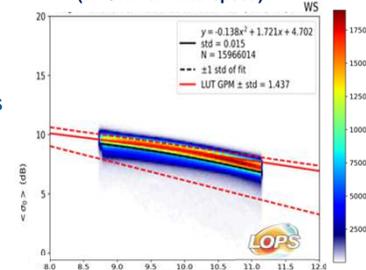
SWH from SWIM nadir data vs MFWAM (3 months of data)



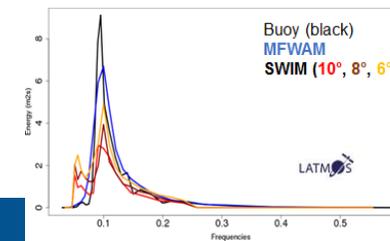
Wind speed from SWIM nadir data vs ECMWF (15 days of data)



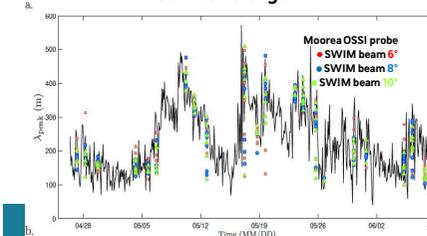
Incidence dependency (all SWH at Wind speed)



Omni directional spectra



Peak wavelength

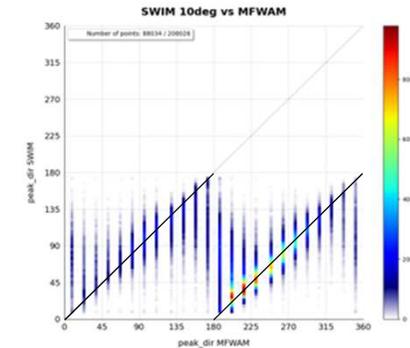
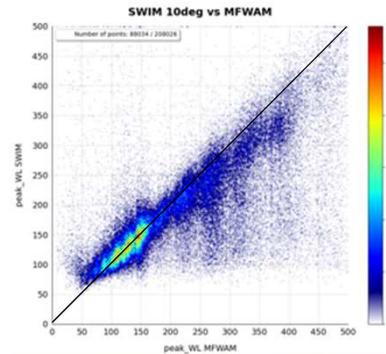
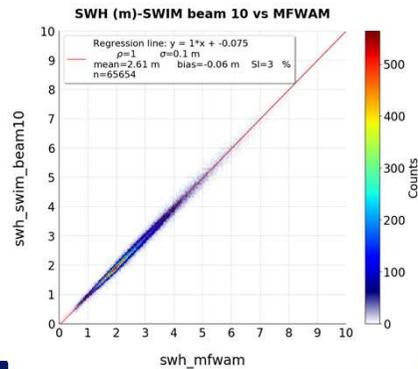
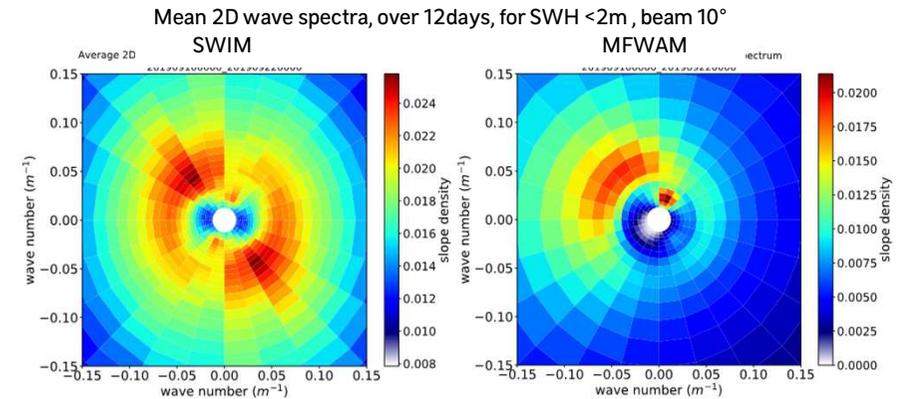


E. Dormy, L. Oruba courtesy

Current CFOSAT SWIM products quality

- ❖ 2D wave spectra
 - All azimuths provided and exploitable
 - Good shape of the spectra
 - Compared to model or other instrument (Sentinel1)

- ❖ Wave parameters SWH, wavelength and direction:
 - Wave identified between 50 and 500m
 - consistent with model and buoys data
 - Strong consistency for SWH, equivalent to nadir SWH
 - Good consistency for wavelength and direction



SWIM CAL/VAL Status

Foreseen activities

- ❖ New antenna gain diagram implementation
 - New method implemented to mitigate limitations of gain diagram measurement accuracy
 - New antenna gain diagram estimated, final tests on going

See L. Hermozo presentation (perspective for signal processing improvement and/or new products)

- ❖ Mitigation of parasite peaks in 1D spectra
 - Filtering method for these peaks proposed, under finalization and test

See D Alraddawi presentation (perspective for signal processing improvement and/or new products)

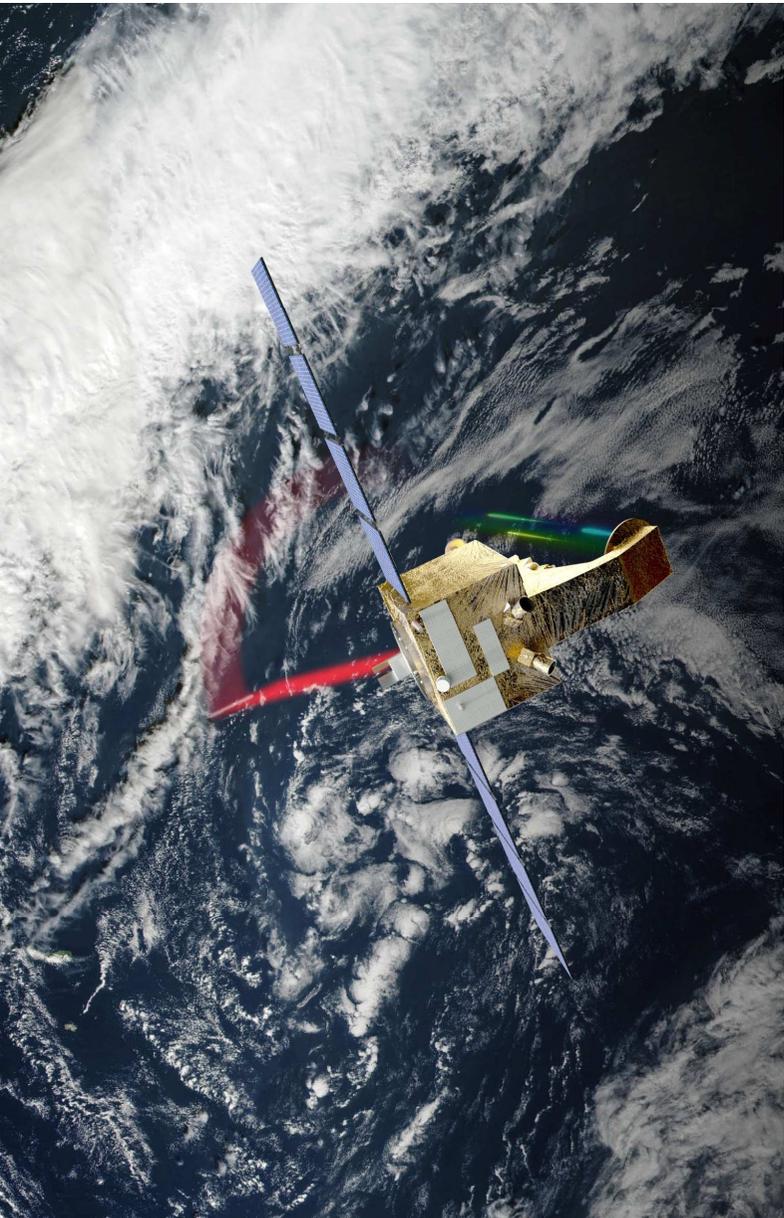
- ❖ Speckle noise correction
 - On-going work to continue improving this correction

See 4 presentations on the subject (perspective for signal processing improvement and/or new products)

- ❖ Alternative MTF algorithm
 - Continuous work to get algorithm closer to the geophysical phenomena

- ❖ In-situ and airborne campaign data exploitation
 - From 2021 February 15th to March 5th :
 - Kuros instrument acquisition on CFOSAT crossover points
 - Simultaneous in-situ data acquired
 - Buoys (flame, carthe, drifting wave and moored)
 - Instruments aboard the boat (stereo cameras, X-band wave radar, polarimetric imagery, large FOV imagery)

See D. Hauser presentation (SWIM assessment and product characteristics)



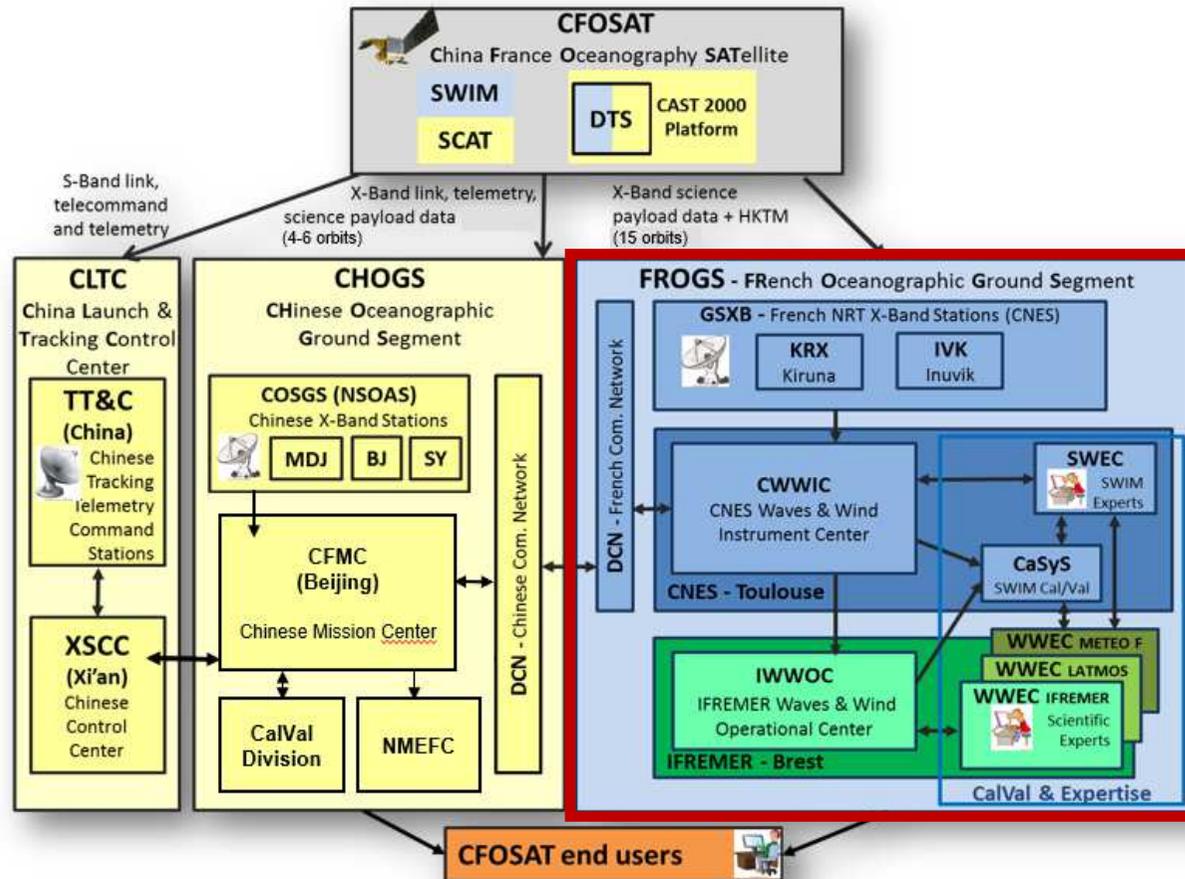
Conclusions

- ❖ SWIM instrument shows good, stable performances
- ❖ SWIM products show consolidated performances
- ❖ Work is continuously performed to further improve the product performance and increase application opportunities.
- ❖ The interest of the CFOSAT mission and its products is well demonstrated
- ❖ Now looking towards scientific use of the data and feedbacks from scientific teams



FROGS STATUS

The FROGS in the System



Processing chains status



SCAT-IPF & SWIM-AWWAIS Timeline



Scientific Data Availability

Requirement:

- ❖ The availability of the Satellite for generating Observation data (Measurement and Calibration) shall be greater than 95 %

From the beginning of life (2019/11/05) till now (2021/01/31): 27 months/810 days

- ❖ Station Keeping manoeuvres (including 1 collision avoidance): 4 days
- ❖ On-board X-band interruption (EPC OFF anomaly): 5 days
- ❖ SCAT switch to redundant (end of December 2019): 9 days
- ❖ SWIM anomaly (2021/01/06): 5 days



Global CFOSAT availability performance:

SCAT: 97.8%

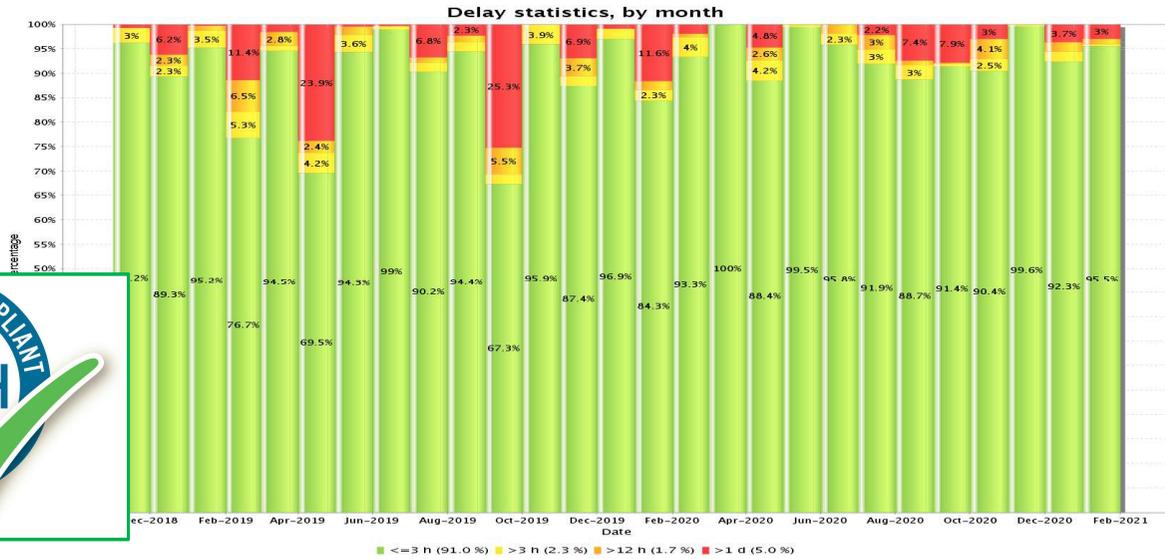
SWIM: 98.3%

Thanks again to good coordination between both operational teams

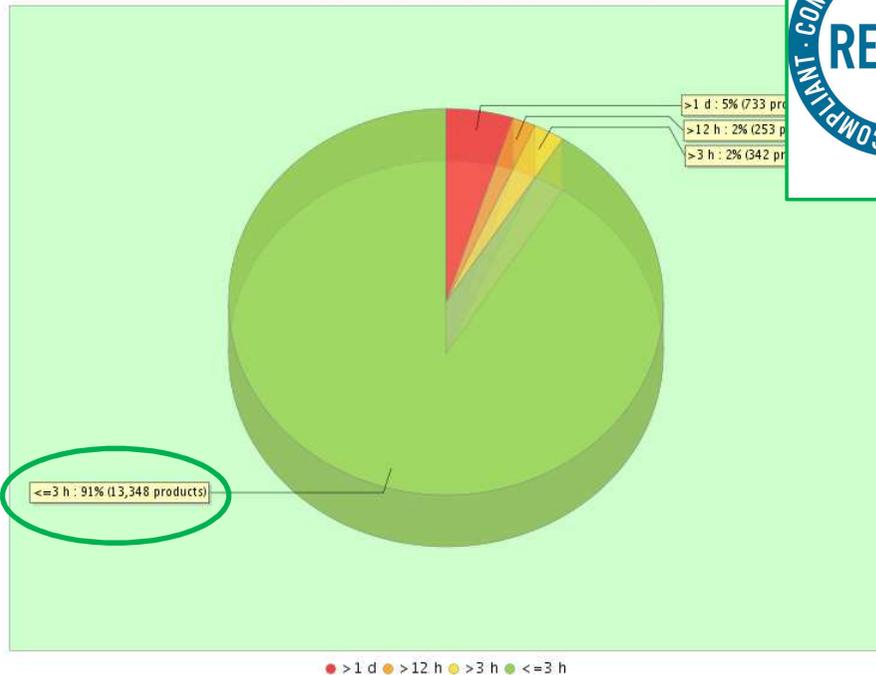
Production status

SWIM-NRT Production delay over 27 months

- ❖ 2018/11/02 – 2021/01/31
- ❖ Requirement: better than 75%



SWIM-NRT Statistics Production Delay



Main events

- ❖ CWWIC Data server (SdS) unavailability: 8 days
- ❖ IT Facilities unavailability (incident/maintenance): 20/13 days
- ❖ SWIM processing: 15 days

Very good performances of the programming loop, the reception function (GSXB) and the IT facilities (HPC)

Very good robustness of SWIM-AWWAIS

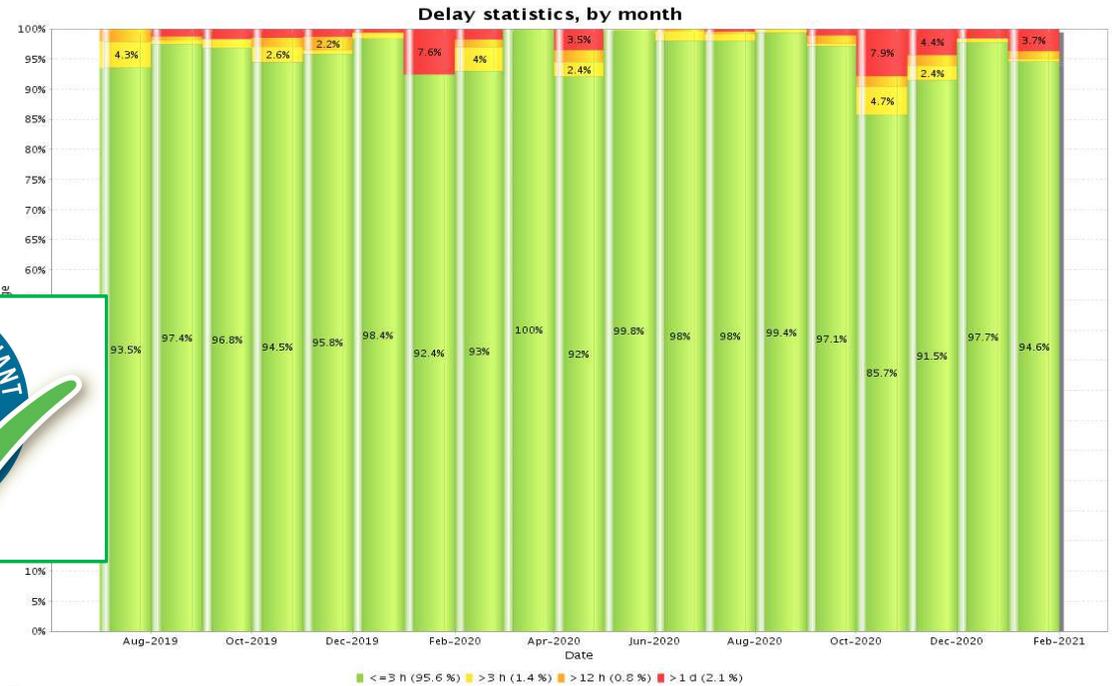
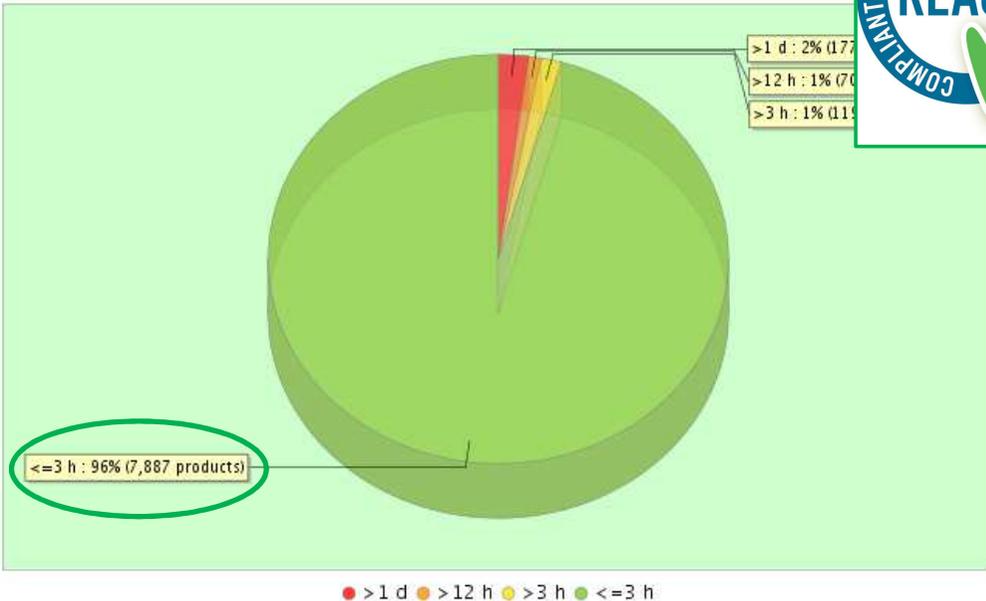


Production status

SCAT-NRT Production delay over 18 months

- ❖ 2019/07/23 – 2021/01/31
- ❖ Requirement: better than 75%

SCAT-NRT Statistics Production Delay



Main events

- ❖ CWWIC Data server (SdS) unavailability: 8 days
- ❖ IT Facilities unavailability (maintenance): few days

Very good performances of the programming loop and the reception function (GSXB)
 Very good robustness of SCAT-IPF 

Availability of the SWIM-AWWAIS 5.1. release since the 16th of November 2020

Comparing with the 4.3. release (2019/07/29)

- ❖ Antenna gain diagram adjustment
- ❖ Better speckle correction
- ❖ Modulation Transfer Function (MTF): from MTF1 to MTF3

Very good level of product quality: nadir and off nadir measurements

- ❖ Ready for a full reprocessing of SWIM products from beginning of life to provide users with the longest time series
 - From 2019/04/25 to 2020/11/16 for users

Reprocessing

- ❖ Reprocessing and verification performed in less than 2 months
- ❖ Reprocessed products available since the end of January (code OP05 in the product name)
- ❖ Reprocessing chain ready to be used after each major SWIM-AWWAIS release. Next planned for beginning of 2022

CFOSAT products are available

- ❖ For CWWIC products
 - On Aviso+ Website:
<https://www.aviso.altimetry.fr/>
 - For SWIM-L2, SWIM-L1B on line on a FTP server:
 - <ftp://ftp-access.aviso.altimetry.fr/cfosat>
 - For all the products (including SCAT), on the long term archive:
 - <https://aviso-data-center.cnes.fr/>
- ❖ For IWWOC products
 - On ODATIS website

AVISO+ Satellite Altimetry Data

Mobile version

MY AVISO+ | DATA | USER CORNER | APPLICATIONS | **MISSIONS** | TECHNIQUES | NEWS | MULTIMEDIA

AVISO+ | MISSIONS | CURRENT MISSIONS | CFOSAT

CFOSAT

The Chinese (CNSA) and French (Cnes) Space Agencies jointly plan a satellite mission devoted to the monitoring of the ocean surface wind and wave, and related ocean and atmospheric science and applications: CFOSAT project (Chinese-French Oceanic Satellite).

The CFOSAT embark two main instruments: the french radar SWIM (Surface Wave Investigation and Monitoring) to determine the direction, amplitude and wavelength of surface waves and the chinese scatterometer SCAT to measure wind speed.

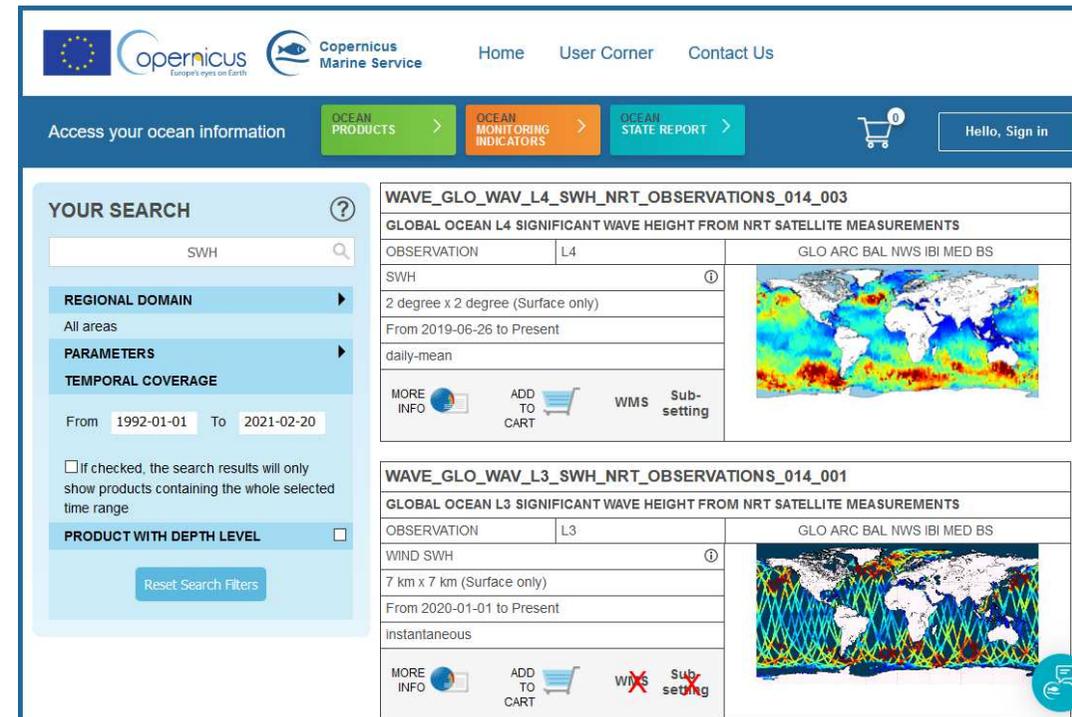
The ground segment is shared between chinese (Mission and Control centers) and french centers (Instrument mission center and waves and wind mission center).

| | |
|--------------|-------------------------------|
| Satellite | CFOSAT |
| Launch on | 29/10/2018 |
| End Date | |
| Altitude | ~500 |
| Inclination | 90° |
| Repetitivity | |
| Agency | Cnes-CNSA |
| Goals | Measure sea state (wind/wave) |
| Link | |

Data dissemination

CFOSAT products are distributed

- ❖ TO NSOAS
 - SWIM-NRT & SCAT-NRT
- ❖ To KNMI/EUMETSAT
 - SWIM-NRT
 - SCAT-L1B for SCAT-L2-NRT processing
- ❖ By EUMETSAT via EUMETCast:
 - To EUMETSAT Member States & ECMWF
 - Only for SWIM-NRT at the time being
 - **Status to be made for SCAT-NRT**
- ❖ To CMEMS Waves-TAC:
 - SWIM-L2P-SWH-Nadir-1Hz products (also available on Aviso+ website)
 - Global L3 and L4 SWH NRT products available on CMEMS website:
 - <https://resources.marine.copernicus.eu/>



The screenshot displays the Copernicus Marine Service website interface. At the top, there are navigation links for Home, User Corner, and Contact Us. Below this, a dark blue navigation bar contains buttons for OCEAN PRODUCTS, OCEAN MONITORING INDICATORS, and OCEAN STATE REPORT, along with a shopping cart icon and a 'Hello, Sign in' button.

The main content area is divided into two sections. The left section, titled 'YOUR SEARCH', shows a search for 'SWH' with filters for REGIONAL DOMAIN (All areas), PARAMETERS, TEMPORAL COVERAGE (From 1992-01-01 to 2021-02-20), and PRODUCT WITH DEPTH LEVEL. A 'Reset Search Filters' button is visible at the bottom of this section.

The right section displays two search results. The first result is 'WAVE_GLO_WAV_L4_SWH_NRT_OBSERVATIONS_014_003', titled 'GLOBAL OCEAN L4 SIGNIFICANT WAVE HEIGHT FROM NRT SATELLITE MEASUREMENTS'. It shows a 2 degree x 2 degree (Surface only) product from 2019-06-26 to Present, with a daily-mean frequency. A world map visualization shows significant wave height data. Below the map are buttons for 'MORE INFO', 'ADD TO CART', and 'WMS Sub-setting'.

The second result is 'WAVE_GLO_WAV_L3_SWH_NRT_OBSERVATIONS_014_001', titled 'GLOBAL OCEAN L3 SIGNIFICANT WAVE HEIGHT FROM NRT SATELLITE MEASUREMENTS'. It shows a 7 km x 7 km (Surface only) product from 2020-01-01 to Present, with an instantaneous frequency. A world map visualization shows significant wave height data. Below the map are buttons for 'MORE INFO', 'ADD TO CART', and 'WMS Sub-setting'.

AVISO Data Users Teams around the world

CFOSAT

❖ After one year

479 users

51 countries



Not amazing but encouraging and promising 🤪

The IWWOC



The **Ifremer Wind and Wave Operation Center (IWWOC)** is the downstream French CFOSAT processing centre, operated by CERSAT (Ifremer Satellite Data Processing and Dissemination Centre) and supported by experts from the Laboratory of Space and Physical Oceanography (LOPS)

IWWOC is co-developed with experts from two associated companies: OceanDataLab (for SWIM products) and eOdyn (for SCAT products)

IWWOC focus is on advanced research product :

- ❖ Delayed mode, long and consistent time series to complete climate data series from other missions
- ❖ Higher level products : L2S to L3/L4 (global fields of wind and wave parameters)
- ❖ Synergy between SWIM and SCAT, alternative processing method and testing
- ❖ Ultimately combination with other missions such as Sentinel-1
- ❖ Resources for CalVal and algorithm development: cross-overs with altimeters/scatterometers/SAR, match-ups with in situ data, dedicated wave hindcast over SCAT & SWIM measurement locations (WW3)



IWWOC Production Status



The IWWOC production centre is now in place and running preliminary versions of IWWOC processing chains. **The IWWOC officially switched to operation phase in November 2020.**

However IWWOC products are still being developed or validated :

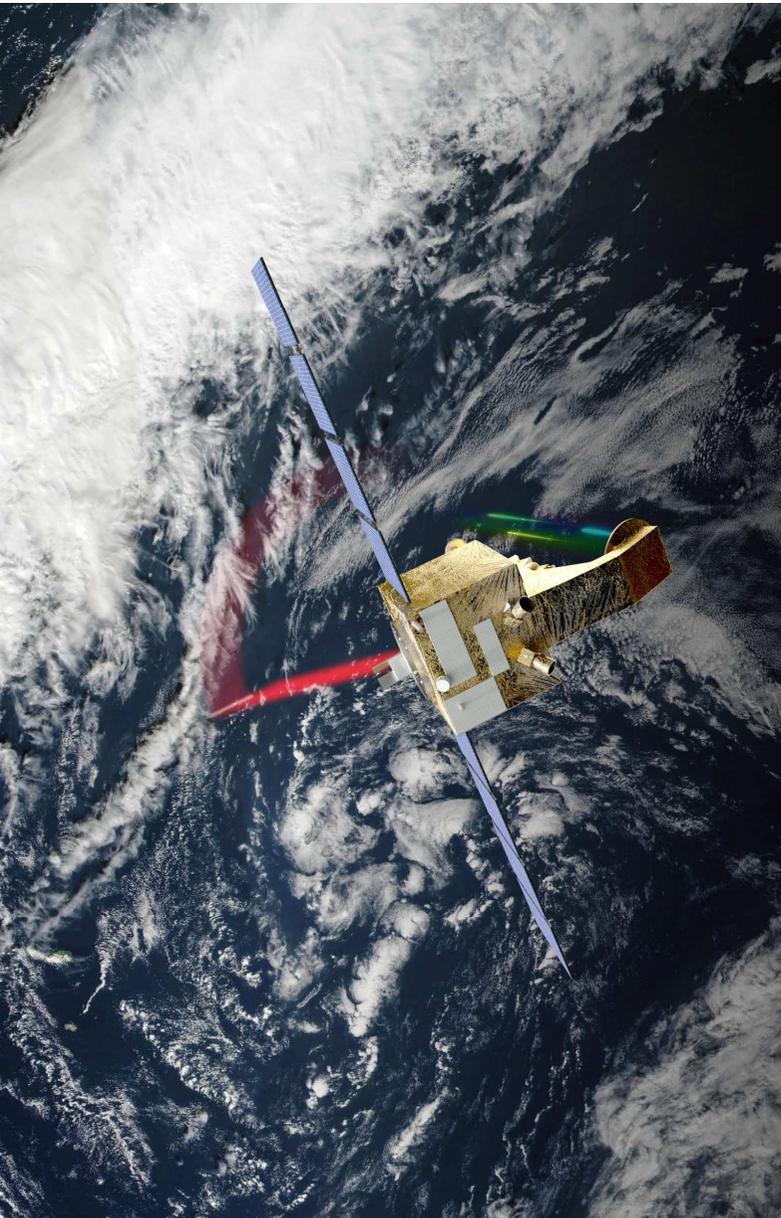
- ❖ Some delay was caused by support to the assessment and investigation of both SWIM and SCAT instruments and products. Several issues with both have occurred in the past months as both instruments are new
- ❖ Some empirical approaches used in our products require sufficient series of continuous and consistent data
- ❖ Combination of SWIM and SCAT data is a new and tentative approach



The open distribution of IWWOC products is planned for mid-2021.

The products will be distributed through **ODATIS** portal, the French federated access to national Ocean data





Conclusions

A FROGS fully operational (for the greater part) since the launch

An excellent operational coordination with China

Very good performances in products generation

- ❖ Routine
- ❖ Reprocessing

Already numerous users registered and interested in CFOSAT

- ❖ Should increase in the coming months

A detailed 3D rendering of the CFOSAT satellite in space. The satellite features a central white and gold body, a large gold thermal blanket, and a long array of solar panels on the right side. The background shows a starry space and the blue and white horizon of the Earth.

CFOSAT

谢谢！ Thank you ! Merci !



BACKUP SLIDES

Systematic quality monitoring

❖ Cyclic reports:

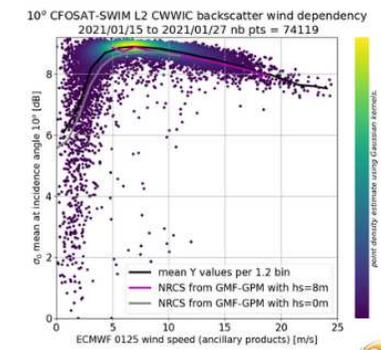
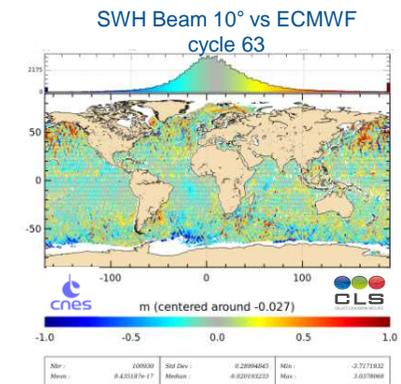
- Predefined diagnosis applied on CFOSAT/SWIM products
- Give a high level assessment of the product quality
 - over the cycle
 - over life time for several diagnosis

➤ CaSyS synthetic reports :

- Instrument/coverage monitoring
- SWIM nadir monitoring (comparison to models, altimeters)
- SWIM off nadir monitoring (comparison to models, instrument sentinel 3)
- <https://www.aviso.altimetry.fr/en/missions/current-missions/validation-reports.html>

➤ LOPS WVEC CFOSAT Calibration/Validation report

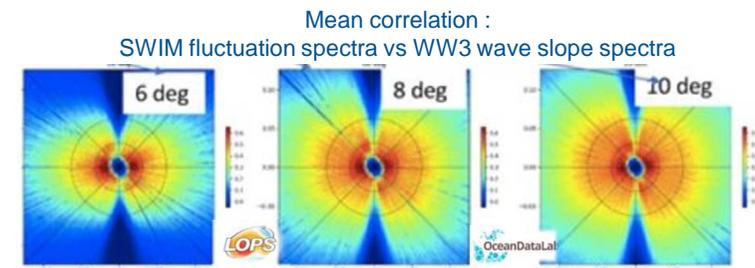
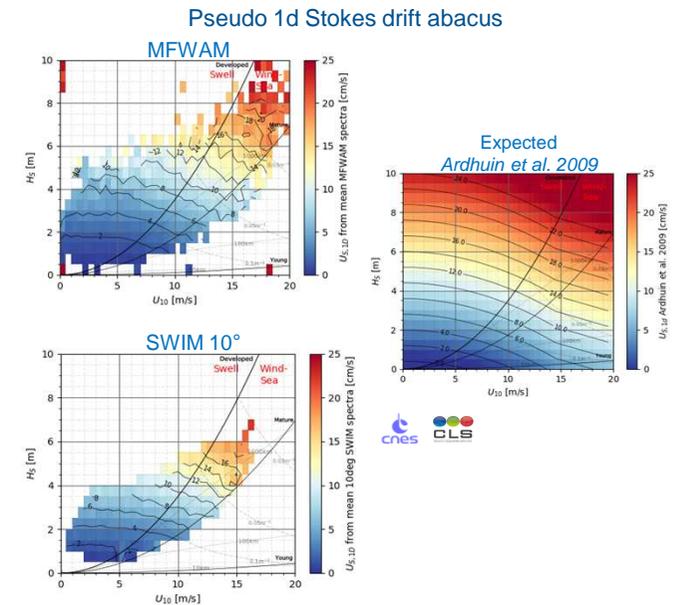
- CWWIC L2 radar : Radar parameters analyses (sample of macrocycles)
- CWWIC L2 waves : waves parameters analyses
- <http://oceanwavesremotesensing.ifremer.fr/cfosat/>



SWIM CAL/VAL process

CAL/VAL activities

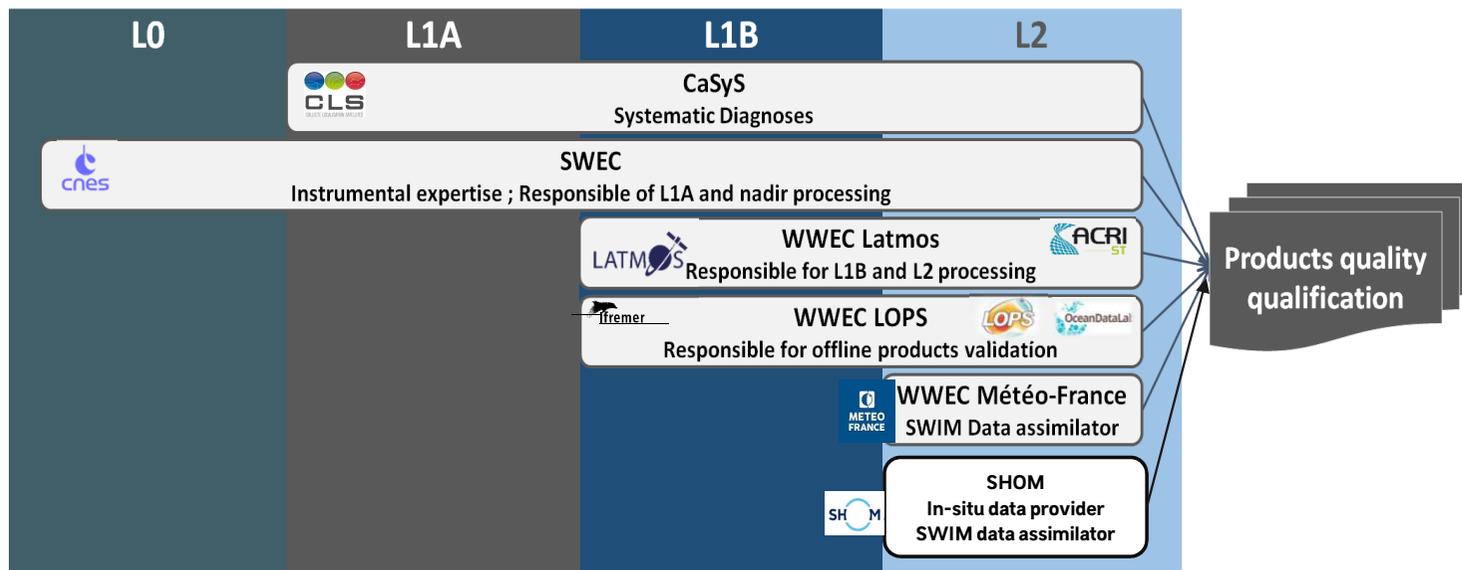
- ❖ Performed by the SWIM CAL/VAL group (composition on next slide)
 - Mid / long term regular analyses
 - Identification of areas of improvement
 - SWIM on-board software anomaly mitigation
 - Antenna gain characterization
 - Speckle noise correction
 - Modulation transfer function
 - CAL/VAL report at the end of the Validation phase (September 2019)
 - Synthesis of performances and limitations observed in the SWIM products
 - Reference article in IEEE TGRS about Swim instrument validation and product assessment (DOI: 10.1109/TGRS.2020.2994372)
 - Algorithm evolution definition
 - 6 AWWAIS issues since launch (see FROGS presentation)



SWIM CAL/VAL proces

CAL/VAL group composition and attribution

- ❖ Six entities working on different level with different point of views
 - From instrument experts to data assimilators
- ❖ Coordination by
 - CNES CFOSAT project scientist : C. Tourain
 - French CFOSAT PI and Co-PI : D. Hauser, L. Aouf



FROGS Operational Organisation



Project

- ❖ Mission management, coordination and reporting
- ❖ Relations with NSOAS and other partners
- ❖ On duty 24/7 service

GSXB

- ❖ SWIM & SCAT PLTM reception
- ❖ 2 X-Band stations management (KRX, IVK)
- ❖ On duty 24/7 service

SWEC

- ❖ SWIM Instrument Performances Assessment
- ❖ Product Quality assessment
- ❖ SWIM Processing improvement
 - With WWECs support



❖ CWWIC exploitation and reporting

- Programming Loop
- SWIM monitoring
- SWIM & SCAT PLTM NRT processing (Level-2)
- Distribution, Dissemination and Archiving
- 6 days a week and [7h-20h] Time slot

❖ CaSyS

- CaVal Systematic SWIM assessment - Reporting
- SWIM-L2P NRT processing for CMEMS



❖ IWWOC exploitation and reporting

- SWIM, SCAT and combined Level 3-4 Products
- Distribution and Archiving
- Product Quality assessment

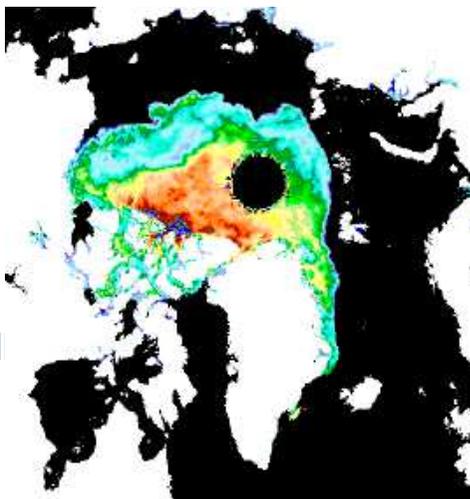


Some IWWOC Products



SWIM

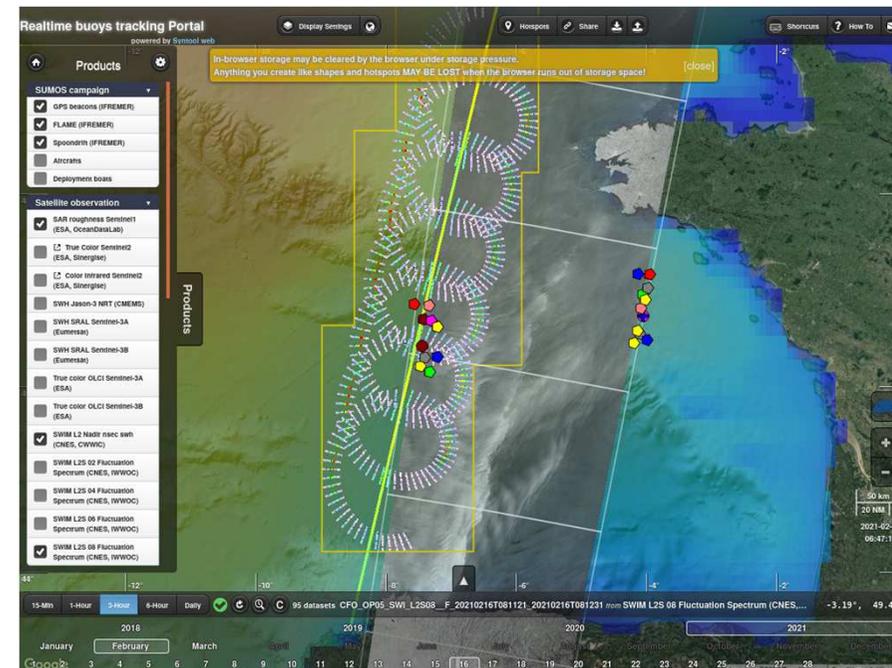
- **L2S** : alternative SWIM L2 product with wave partitioning along each beam « ribbon », empirical speckle correction and MTF. Supports analysis of wave in complex situations such as crossed swell or wave deflection by currents



IWWOC SCAT backscatter map for ice type discrimination

SCAT

- **Sea Ice Maps** : maps of sea ice backscatter for first year / multi-year ice screening extending 30 year multi-mission series starting in 1991 with ERS-1
- **Wind L2S** : alternative L2 wind product taking into account the sea state and nadir observation provided by SWIM
- **Wind L3** : geostatistical analysis to produce gap free daily wind fields combining multiple L2(S) products



IWWOC SWIM L2S with collocated buoys and S-1 SAR from SUMOS campaign (16th Feb.)

IWWOC SCAT Wind Products : L2B swath product and combined L3 daily wind field

