
SWOT-Nadir validation and cross calibration activities

Executive Summary - Annual Report 2024

Reference: SALP-RP-MA-EA-23679-CLS

Issue: 1.2

Date: May 27, 2025

Contract: SALP 2023-24 No 221332

Customer:	CNES	Document Ref.:	SALP-RP-MA-EA-23679-CLS
Contract :	SALP 2023-24 No 221332	Date:	May 27, 2025
		Issue	1.2

Project:	MISSION PERFORMANCE SERVICE FOR SN MISSION		
Title:	SWOT-Nadir validation and cross calibration activities Annual Report 2024		
	Name	Company	Date
Author(s):	N. Kientz A. Deniau & H. Roinard T. Pirotte	ALTEN for CLS CLS CLS	
Approved by:	F. Bignalet-Cazalet	CNES	
Application authorized by :			

Change Log

Version	Date	Changes
1.0	March 31, 2025	Creation
1.1	May 12, 2025	Several improvements
1.2	May 27, 2025	Executive report



Acronyms

AMR	Advanced Microwave Radiometer
CLS	Collecte Localisation Satellites
CMEMS	Copernicus Marine Service
CNES	Centre National d'Etudes Spatiales
CNG	Consigne Numerique de Gain (= Automatic Gain Control)
C2N	Cryosat-2
DAC	Dynamical Atmospheric Correction
DEM	Digital Elevation Model
DV	Default Value
DIODE	Détermination Immédiate d'Orbite par Doris Embarqué
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
DUACS	Data Unification and Altimeter Combination System
ECMWF	European Centre for Medium-range Weather Forecasting
FES	Finite Element Solution
GDR	Geophysical Data Record
GIM	Global Ionosphere Maps
GMSL	Global Mean Sea Level
GOT	Global Ocean Tide
GPS	Global Positioning System
IGDR	Interim Geophysical Data Record
JPL	Jet Propulsion Laboratory (Nasa)
L2P	Along-track Sea Level Anomalies Level-2+
MLE	Maximum Likelihood Estimator
MOE	Medium Orbit Ephemeris
MQE	Mean Quadratic Error
MSS	Mean Sea Surface
OGDR	Operational Geophysical Data Record
PLTM	PayLoad TeleMetry
POE	Precise Orbit Ephemeris
POS-3C	POSEIDON-3C
SALP	Service d'Altimétrie et de Localisation Précise
Sigma0	Backscatter coefficient
SHM	Safe Hold Mode
SSH	Sea Surface Height
SSHA	Sea Surface Height Anomalies
SLA	Sea Level Anomaly
SLR	Satellite Laser Ranging
SSR	Solid State Recorder
SSB	Sea State Bias
STD	Standard Deviation
SWH	Significant Wave Height
TM	TeleMetry
WTC	Wet Tropospheric Correction

Table of Content

1 Executive Summary 1

1.1. Data Availability 1

1.2. Data Validity 2

1.3. Sea Wave Height 3

1.4. Wind Speed 4

1.5. Sea Level Anomalies 5

1.6. Performances at crossover points 5

1.7. Known issues 8



List of Figures

1	<i>SWOT Nadir data availability over ocean (per day)</i>	1
2	<i>SWOT Nadir ocean data editing average by day.</i>	2
3	<i>SWOT Nadir data editing by thresholds over ocean average by day.</i>	2
4	<i>Monitoring of significant wave height</i>	3
5	<i>Monitoring of altimeter wind speed</i>	4
6	<i>Monitoring of altimeter wind speed difference to ERA5 model</i>	4
7	<i>Cyclic monitoring of along-track Sea Level Anomaly (SLA)</i>	5
8	<i>Mean SSH difference at crossovers</i>	5
9	<i>Std SSH difference at crossovers</i>	6
10	<i>Mean SSH difference at crossovers between SWOT Nadir MLE4 and Sentinel-6 MF LR MLE4</i>	7
11	<i>Mean SSH difference at crossovers between SWOT Nadir MLE4 and Sentinel-6 MF LR MLE4 for a winter cycle (left) and a summer cycle (right)</i>	7
12	<i>STD Daily monitoring of SSH difference at crossovers between SWOT Nadir MLE4 and Sentinel-6 MF LR MLE4</i>	7

1 Executive Summary

1.1. Data Availability

The behaviour of SWOT Nadir over ocean is good. In average SWOT Nadir provides 97.4% of measurements for GDR over 023 cycles and 97.45% for IGDR over 025 cycles.

A change in behavior is visible before and after September 12, 2023. Just after the orbit change to the Science phase, the altimeter parameters were not fully adapted to the new altitude, mainly affecting measurements at high latitudes. The data availability rate was slightly lower during this period, with missing data at latitudes greater than 66°. After the EEPROM update on September 12, 2023, the availability rate slightly increased. The data gap observed at the beginning of cycle 4 (September 21, 2023 to September 27, 2023) was due to an SSR stop caused by a power supply anomaly.

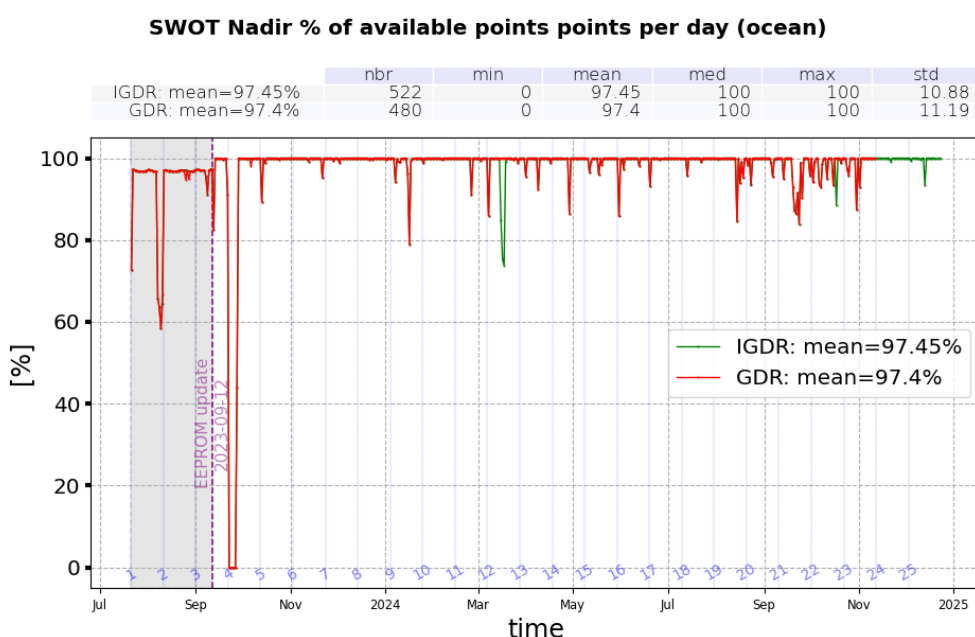


Figure 1: SWOT Nadir data availability over ocean (per day)

1.2. Data Validity

The average of total valid measurements over ocean is 82.54% (see Figure 2).

EEPROM update on 12 Sep. 2023 (C003) has a slight impact on edited data because more data near ice lands are available.

Over the 23 cycles, in average 14.79% of data were edited by ice over ocean. Over the studied period, no

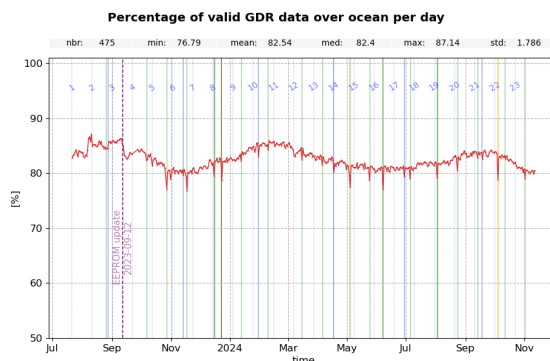


Figure 2: SWOT Nadir ocean data editing average by day.

anomalous trend is detected, only the annual seasonal signal is visible mainly due to ice coverage annual variations in north and south hemispheres.

After quality flag analysis, instrumental parameters have also been analyzed from comparison with thresholds.

The average of total edited measurements following threshold criterion is around % (Figure 3). Note that all outliers are on maneuver slots (colored lines).

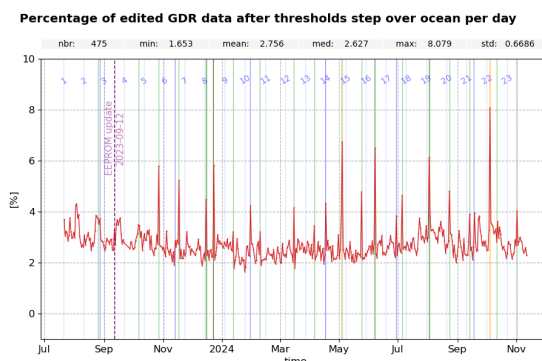


Figure 3: SWOT Nadir data editing by thresholds over ocean average by day.

1.3. Sea Wave Height

SWOT Nadir SWH is centered around 2.57 m for MLE4 (figure 4, top left). Comparison to ERA5 model shows a jump around cycle 10 that affects GDR and IGDR, it is linked to the introduction of Cryosat-2 in ERA5 model and it is also visible in other mission as Sentinel-6A-MF. The mean of differences tends to be higher after cycle 10 (figure 4, bottom left) while the standard deviation tends to be slightly reduced.

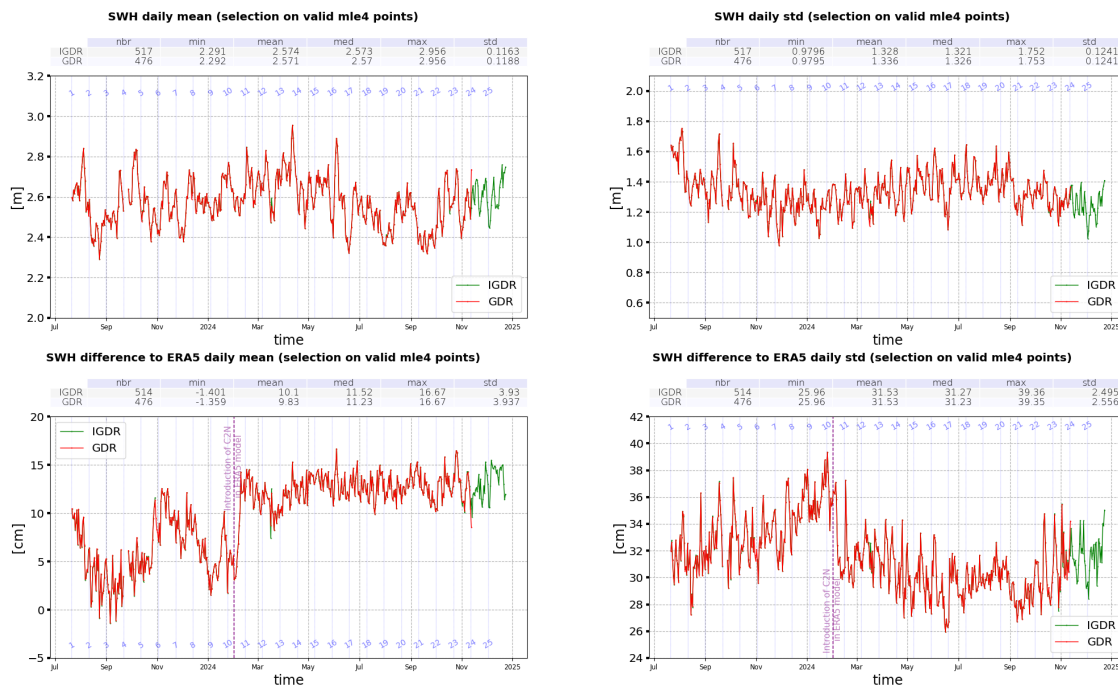


Figure 4: Monitoring of significant wave height

1.4. Wind Speed

For the current version of GDR, wind speed are not fitted to SWOT Nadir data, but the same biases as for Jason-3 GDR-F are applied. As a consequence, wind speed estimations are not aligned with ERA5 model in the GDR-F v1.04 version (figure 6).

The increase for IGDR of altimeter wind speed is explained by an update of the characterization file of the altimeter applied to IGDR from 2023-10-09 23:24:06 (Cycle 4 Pass 509). The daily average from cycle 001 to cycle 023 shows the wind speed values centered around 8.51 m/s for MLE4 (figure 5).

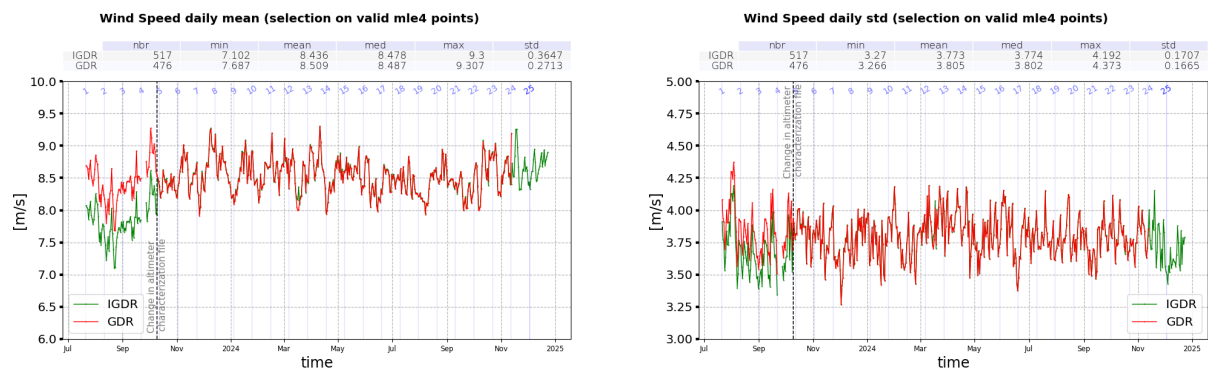


Figure 5: Monitoring of altimeter wind speed

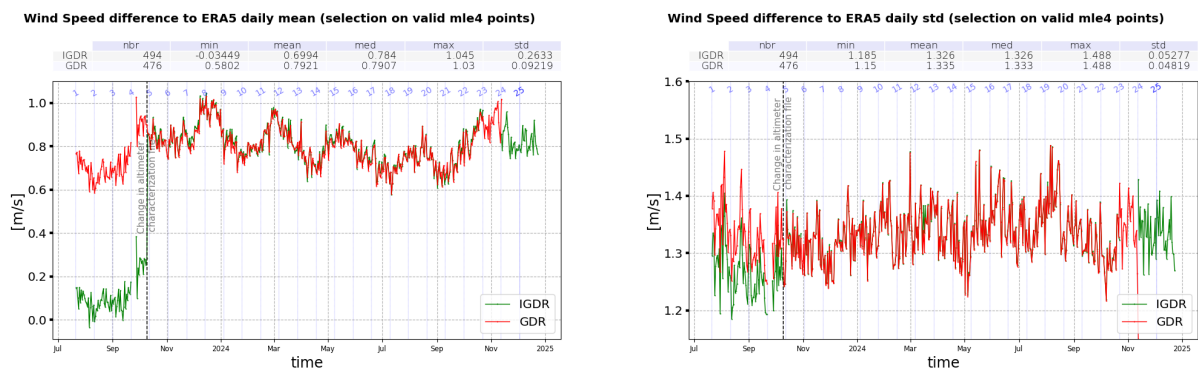


Figure 6: Monitoring of altimeter wind speed difference to ERA5 model

1.5. Sea Level Anomalies

SWOT Nadir shows an good stability in terms of SLA standard deviation.

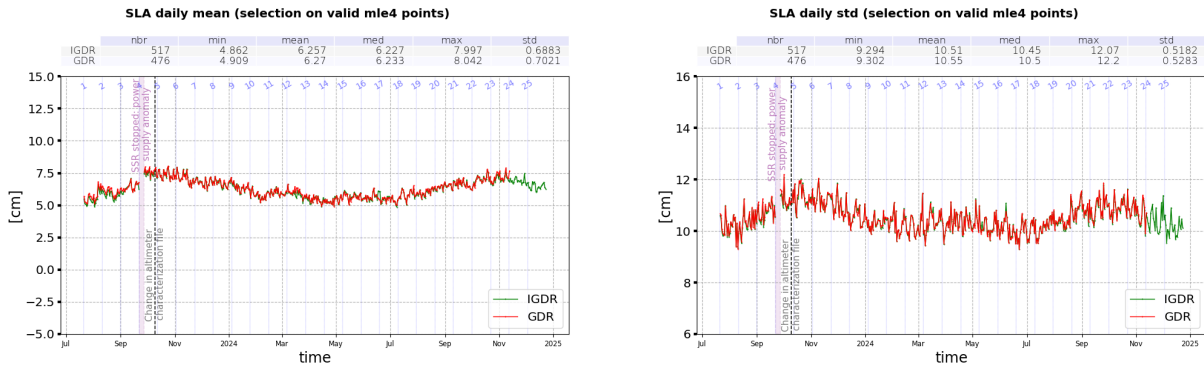


Figure 7: Cyclic monitoring of along-track SLA

1.6. Performances at crossover points

1.6.1. Monomission crossovers

Mean of Sea Surface Height (SSH) differences at crossovers is almost null showing the stability of measurements for this diagnostic. After data editing, applying additional geographical selection and SWOT Nadir standards, the crossover standard deviation for the period between cycle 001 and cycle 023 is about 5.03 cm in MLE4.

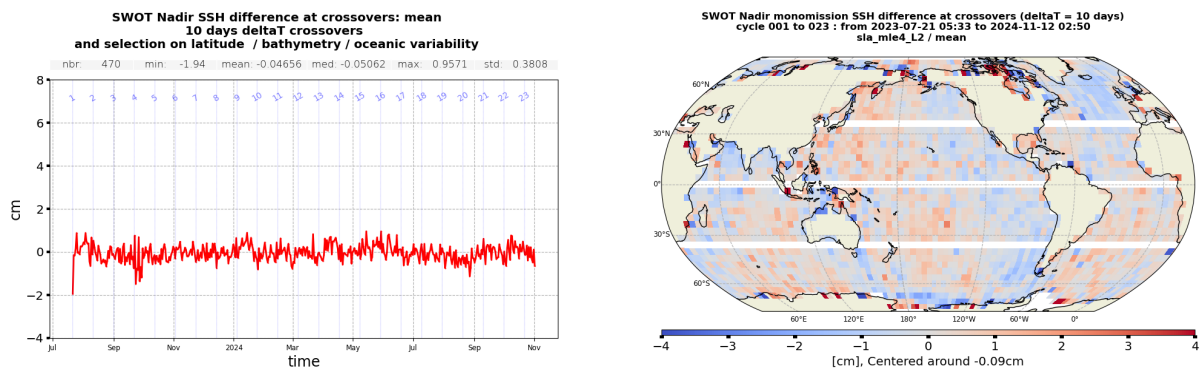


Figure 8: Mean SSH difference at crossovers

The daily standard deviation or variance of SSH crossovers differences are plotted in figure 9 after applying geographical criteria (bathymetry, latitude, oceanic variability).

This metric allows to estimate the system noise by dividing by $\sqrt{2}$ (which leads to 3.56 cm).

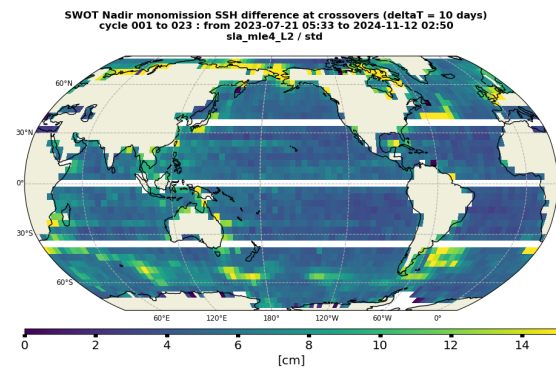
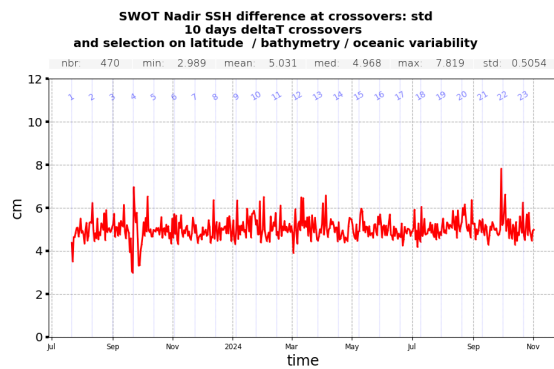


Figure 9: Std SSH difference at crossovers

1.6.2. Multimission crossovers

Mean SLA differences at SWOT Nadir/Sentinel-6A-MF crossovers is quite stable and around 1.015 cm in average. Figure 11 shows seasonal differences.

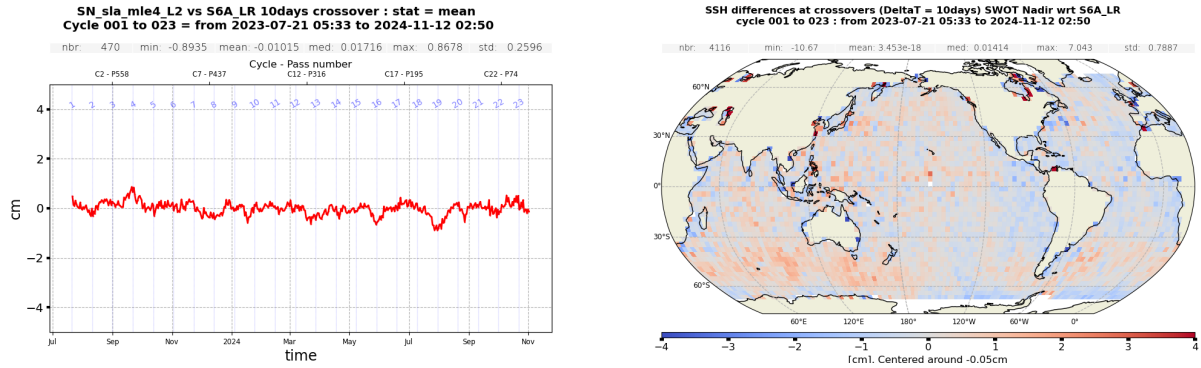


Figure 10: Mean SSH difference at crossovers between SWOT Nadir MLE4 and Sentinel-6 MF LR MLE4

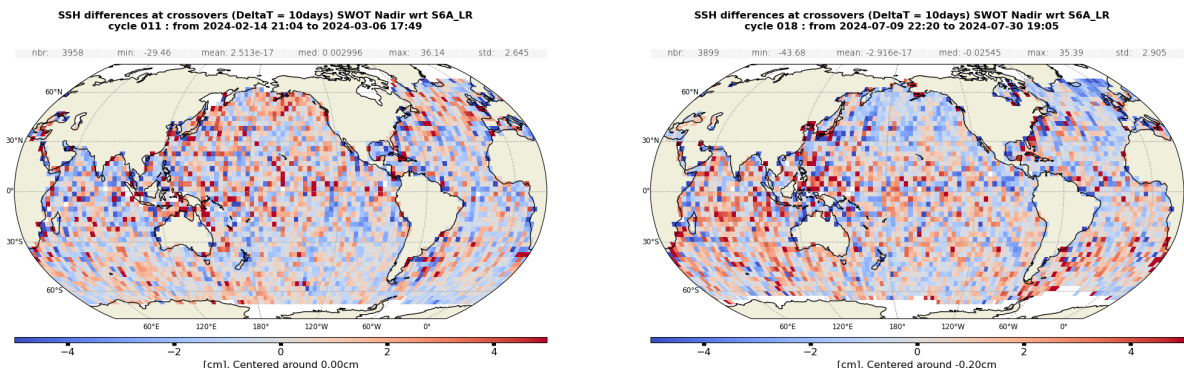


Figure 11: Mean SSH difference at crossovers between SWOT Nadir MLE4 and Sentinel-6 MF LR MLE4 for a winter cycle (left) and a summer cycle (right)

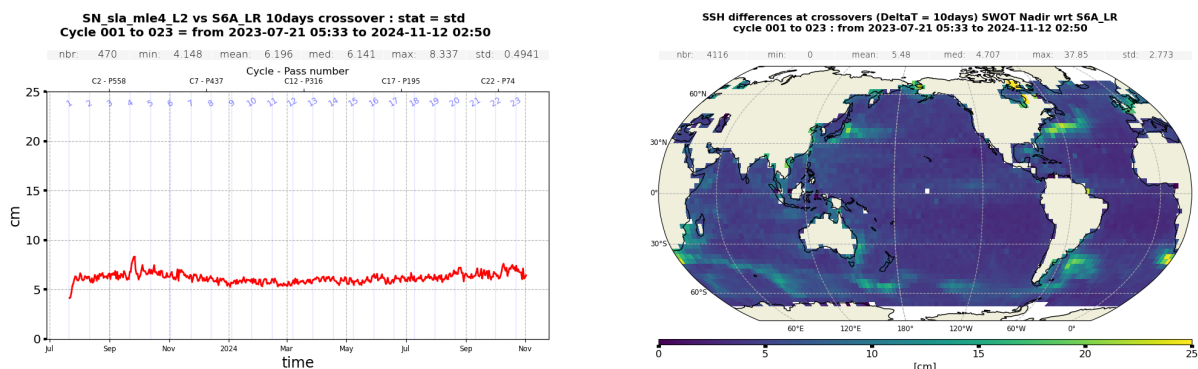


Figure 12: STD Daily monitoring of SSH difference at crossovers between SWOT Nadir MLE4 and Sentinel-6 MF LR MLE4

1.7. Known issues

Known issue: The current interpolation of radiometer data on the nadir track currently requires the two AMR sides to be defined and valid. When one AMR side is invalid (`quality_flag_rad_wet_tropo_cor_qual`), the nadir WTC can be affected by interpolation artifacts. Users who want to remove this subset of measurements can check the validity of the radiometer data and flags in the Radiometer L2 product (L2 RAD). In the next release, the SWOT Nadir processing will be updated to natively handle this border case: the radiometer flag (`rad_wet_tropo_cor_interp_qual`) in the L2 NALT will inform end-users of this degraded radiometer interpolation. In a future release, we plan to revisit the radiometer interpolation algorithm to mitigate or remove interpolation artifacts altogether.

Known issue: Users should also keep in mind that estimated wind speed has a 80cm bias with respect to the model until wind calibration is performed.