Barotropic corrections for SWOT : FES2022 and DAC

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SWOT meeting

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Introduction

Geophysical corrections as tide and DAC are mandatory to remove the corresponding high frequency ocean signal and isolate other oceanic variability from altimeter measurements.

Accuracy of both tide and DAC models has been much improved for the last 30 years, and a specific effort has been done recently with the development of **FES2022** tide model.

A new **operational DAC V4.0** has been deployed recently also allowing more accurate surge simulations thanks to a better bathymetry field and some model improvements.

In parallel, a specific DAC dedicated to SWOT 1day CalVal phase has been computed.

=> We present the last validation results for theses geophysical corrections

=> We also present some preliminary analysis using SWOT 1day data

Dynamic Atmospheric Correction for SWOT

DAC removes the high frequency ocean signal forced by the atmosphere and aliased into lower frequencies due to the low time sampling of the satellites

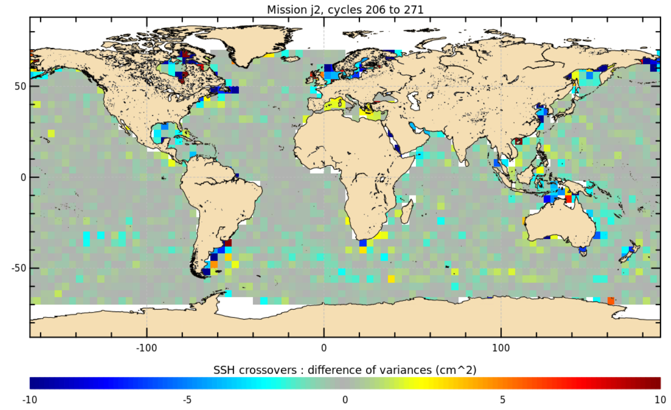
DAC = optimal combination of high frequencies of barotropic model and low frequencies of IB

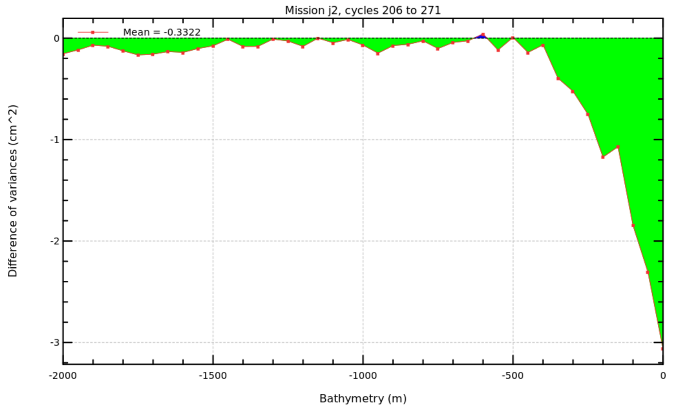
HF/LF cut-off frequency of the operational DAC is 20 days for all missions, and remaining HF signal is removed by LWE in L3 and L4 multi-missions altimeter databases

Operational DAC V4 is available since 09/08/2023 for DT products (since 29/08/2023 for NRT/RT products), for all missions :

- TUGO model forced by ECMWF analysis (6-hours)
- Improvement of the bathymetric field => **use FES2014 bathymetry**
- global FE mesh has ~15km resolution in coastal regions (AVISO-HR)
- Output grids = ¼°, 6h
- **=> significant improvement in shallow waters**

Variance difference when using the new DAC V4 solution instead of the operational DAC V3.5.1 solution, over 2 years of Jason-2 crossover (left) and SLA (right) data in cm^2





Dynamic Atmospheric Correction for SWOT

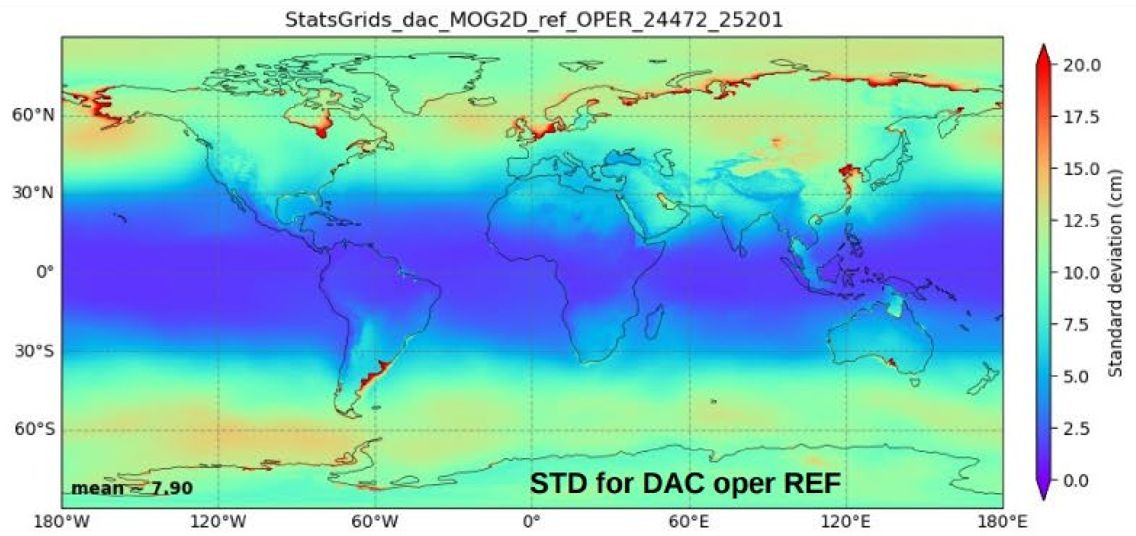
Issues raised with the use of DAC for SWOT:

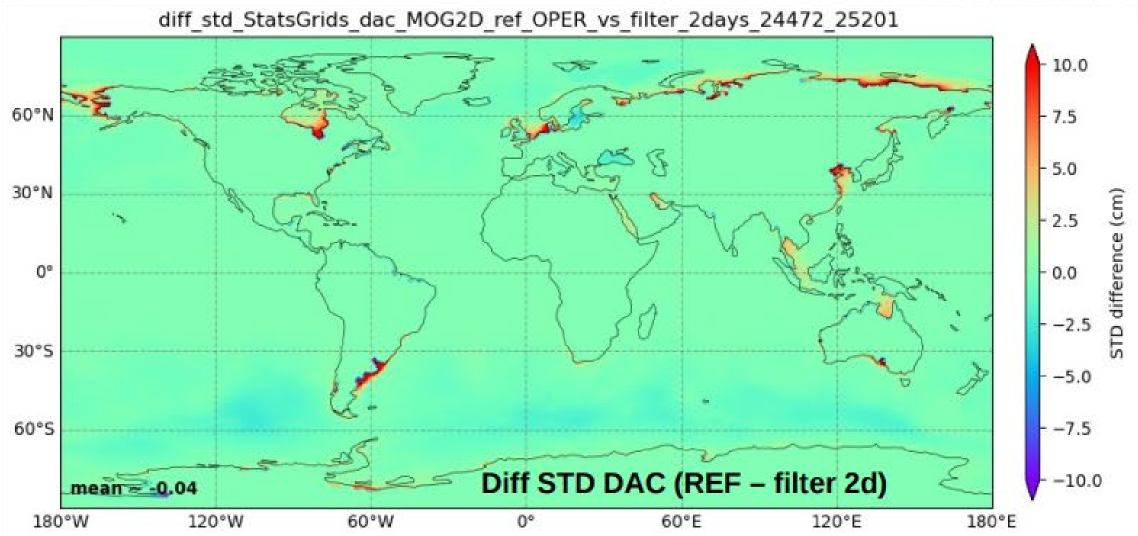
- Operational DAC is not adapted for SWOT-1day phase => **2-days Nyquist period**
- Need to compute a 2-days filtered DAC to be fully consistent with SWOT-1day sampling
- Do we need to compute a 42-days filtered DAC for the SWOT science phase ? Or is classical operational DAC sufficient for all applications ? What are users needs ?
- Will SWOT data point out some new very HR surge variability that should be corrected by a specific or improved DAC solution ?

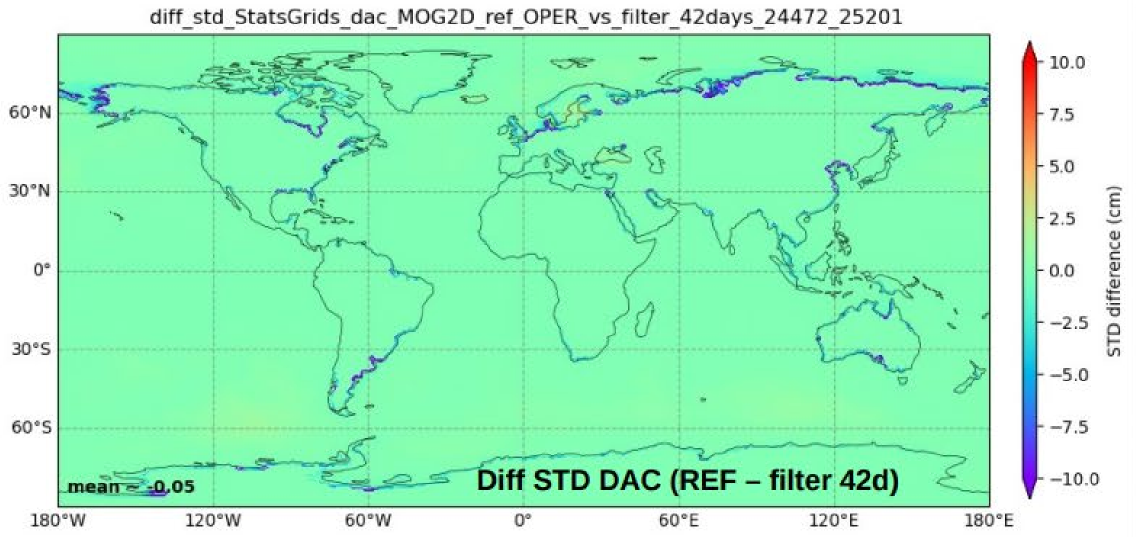
Survey about DAC for SWOT sent in sept. 2022

- Only 7 answers ...
- Most users would use a 2-days DAC and a 42 days DAC if available
- But they still need to have access to the operational 20-days DAC
- They also demand to access to the non-filtered slev of the DAC to be able to test any other filtering, or to the SLEV_HF and IB_BF parts separately

Impact of the different filtering frequencies on DAC







- DAC OPER: strong variability at HLat + shallow waters
- DAC-42d : stronger variability in shallow regions, particularly in Arctic
- DAC-2d : lower variability in shallow waters; impact of ERA5 1h forcing is small (<± 1cm)

=> computation of a DAC-2d time series

DAC 2-days dataset

DAC computed from **MOG2D** slev with **6h-ECMWF** forcing (like operational DAC)

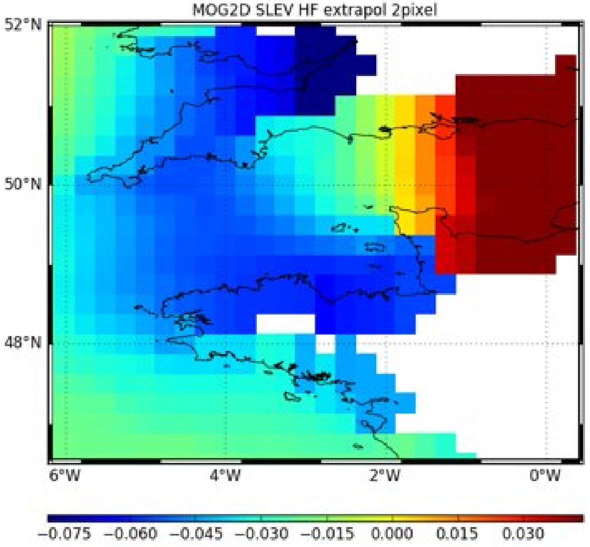
On 1day **SWOT CalVal period: 01-07/2023**

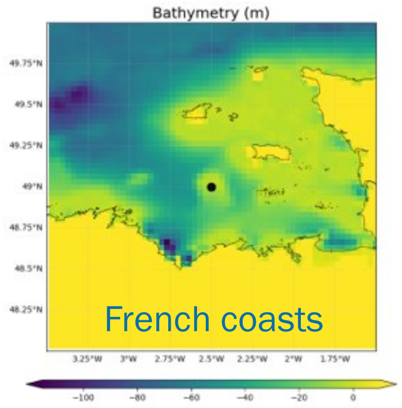
Steps for DAC computation :

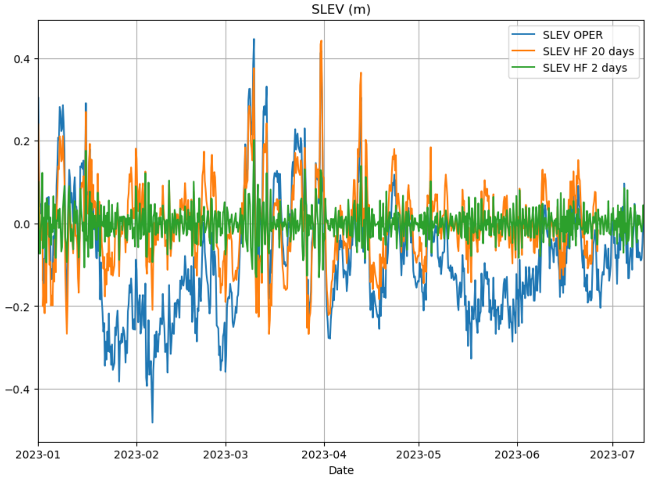
- 2 days low-pass filtering of inverted barometer
- 2 days high-pass filtering of sea level
- Filtered sea level extrapolated on 2 pixels => better coastal coverage

=> **dataset will be available on AVISO in october 2023**

Extrapolation on 2 pixels

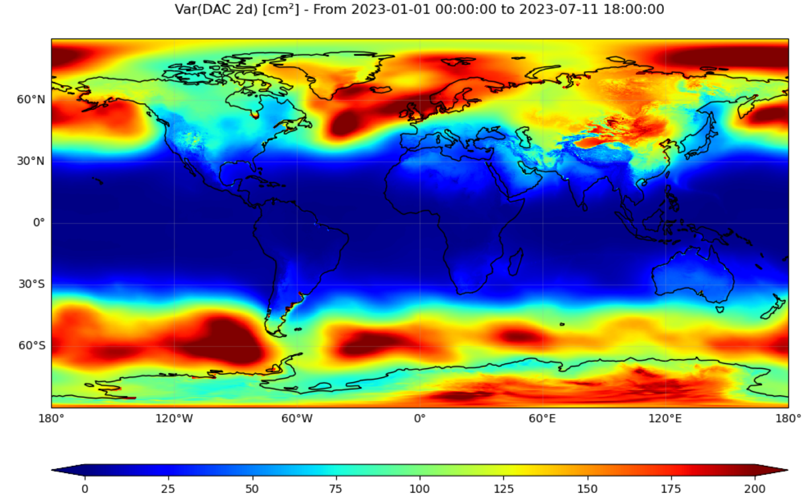




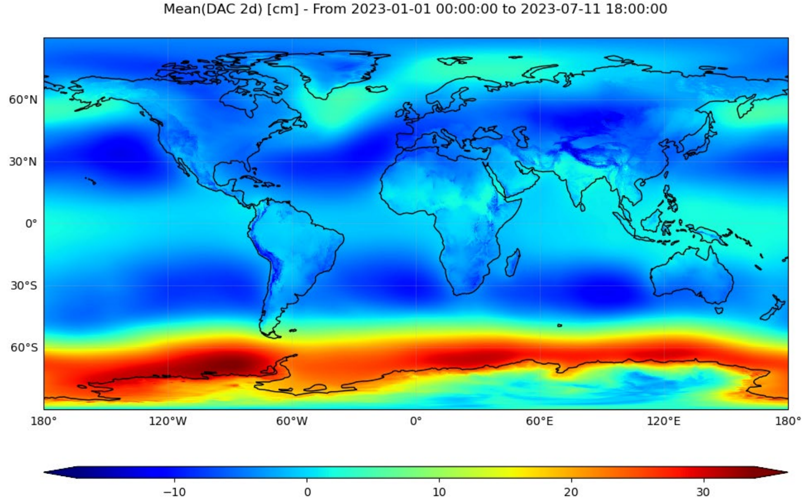


DAC 2-days dataset

Variance (cm²)



Mean (cm)



Validation performed with :

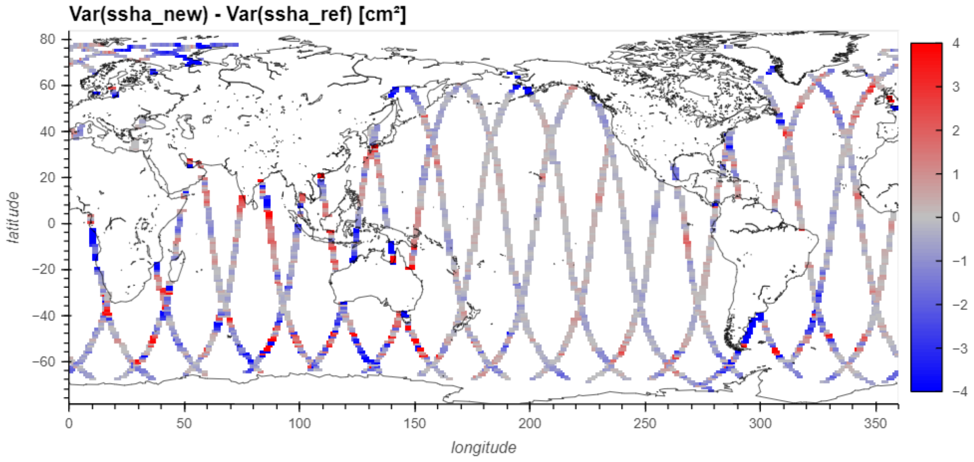
- 1-day SWOT CalVal period : 01-07/2023
- 1°x1° spatial boxes with number of valid data > 200 pts

ssha_ref = ssha_mle4 + dac_oper – **ib_unfilt**

ssha_new = ssha_mle4 + dac_oper – **dac_filt_2days**

=> global reduction of the ssha variance, although some noise is visible

Variance reduction for 1day SWOT nadir data (cm²)



Mean	Min	Max
-0.67 cm²	-218 cm²	22cm²

Global statistics of variance differences

Barotropic tide correction for SWOT

FES2014b tidal model is available in present SWOT product versions

New global tidal model **FES2022** has been developed and validated these 3 last years

FES2022 is characterized by an improved bathymetry and a globally enhanced HR mesh :

- Off shore resolution : 30 km
- Shelf resolution : 10 km
- Continental slope resolution : 6 km
- Coastal resolution : 4 km and until 2km-500m locally

A specific loading tide solution has been computed

Validation shows significant improvement for both tidal elevations and currents

FES2022 is SWOT-resolution friendly in coastal zone although some issues can still remain

=> a specific validation on coastal regions has been performed

=> analysis and comparison with SWOT 1-day dataset have started

FES2022 – global validation

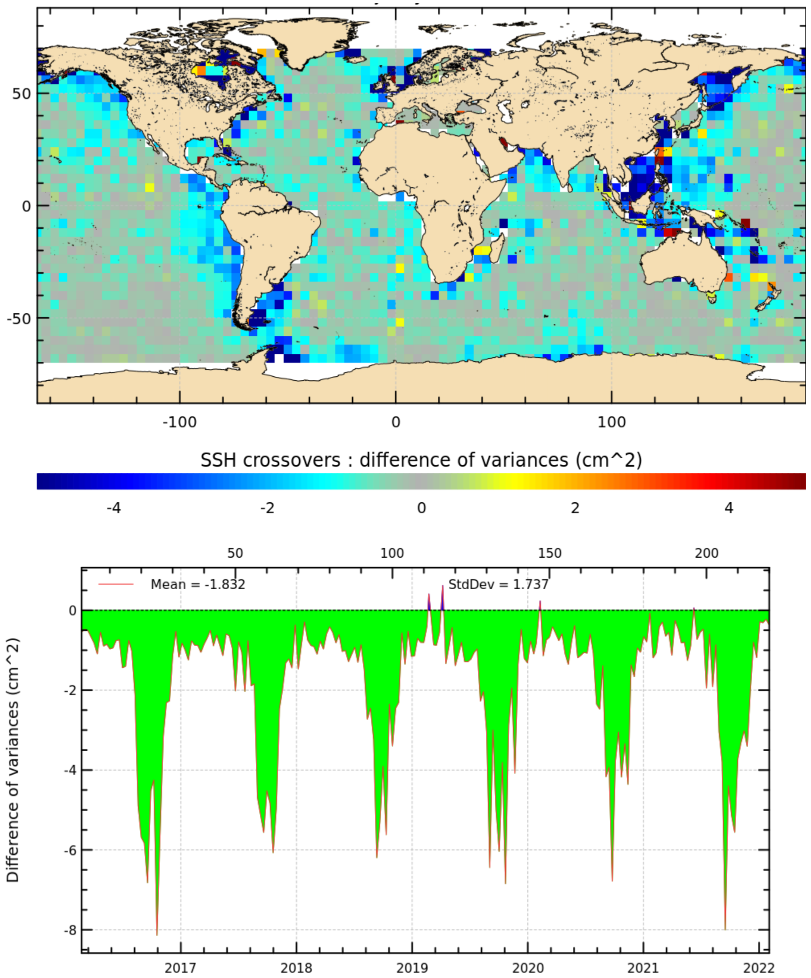
Statistics computed on several years & several altimeter missions (Jason-3, Cryosat-2, AltiKa)

=> strong variance reduction when using FES2022 model instead of FES2014

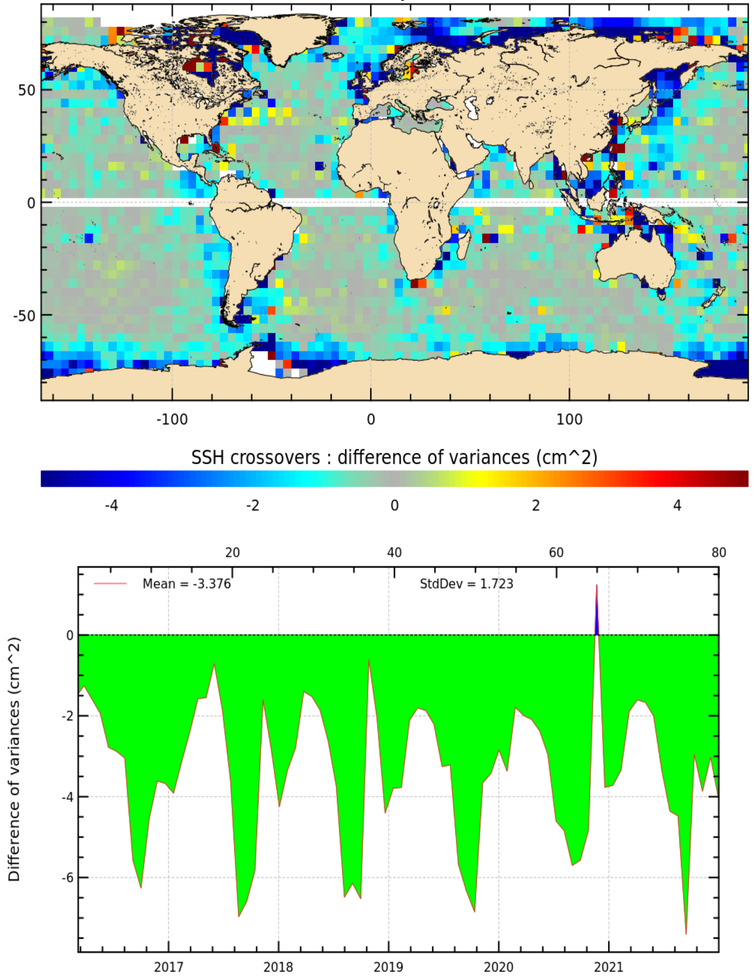
=> strong variance reduction in shallow waters and even in deep regions

=> recommandation to use FES2022 tidal correction on global ocean

J3 crossovers variance reduction when using FES2022 instead of FES2014b (cm²)



S3A crossovers variance reduction when using FES2022 instead of FES2014b (cm²)



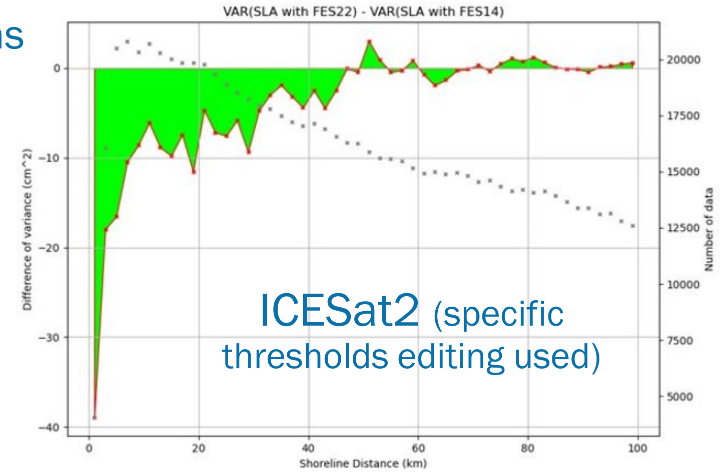
FES2022 – coastal validation versus FES2014b

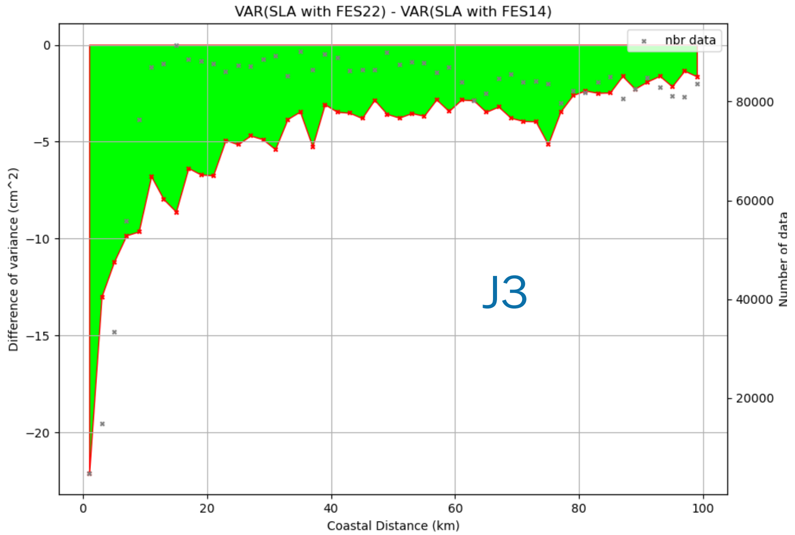
Statistics computed on 2 years datasets (10 months for ICESat2) + several altimeter missions (Jason-3, Cryosat-2, AltiKa).

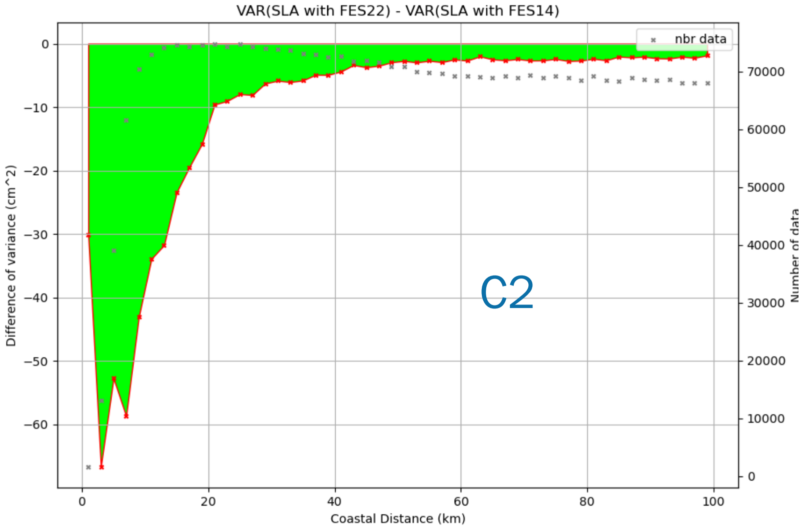
Stronger reduction of SLA variance when getting closer to the coasts (< 100 km).

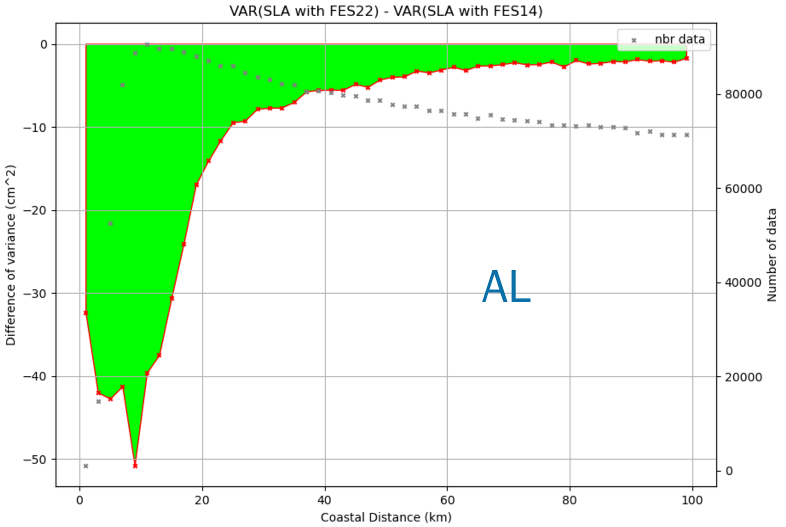
The variance reduction reaches –20 cm² (J3) to –50 cm² (AL / C2).

=> recommandation to use FES2022 model for coastal studies









FES2022 prediction code

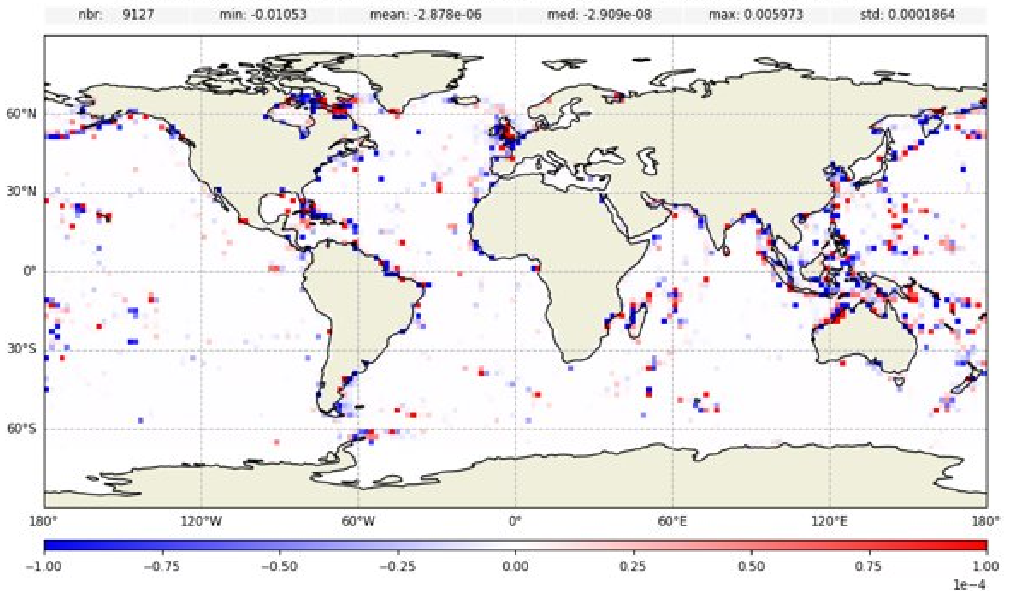
Libfes available on **AVISO** :

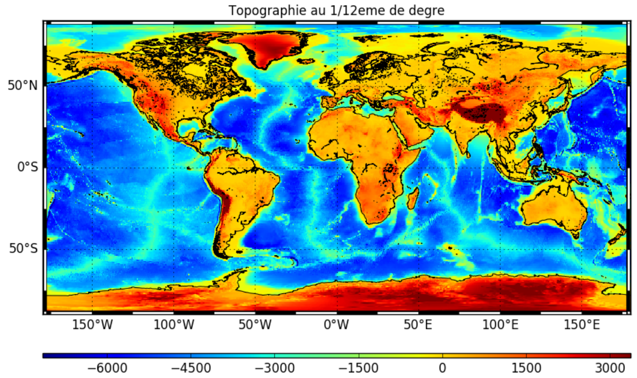
- C library with some python examples
- Deals with <u>cartesian</u> grids only
- Uses Schureman definitions for the astronomic angles

Pyfes : new library developed to deal with unstructured grids

- C++
- Deals with <u>cartesian</u> grids + <u>unstructured</u> grids
- Optimized processing + multi-threading
- Uses Schureman by default and proposes also Meeus calculation
- Available for experts via **HPC/GECO** (CNES)

VAR (SSH FES22 LGP2) - VAR(SSHA FES22 Cartesian) [m²]





Differences between FE and cartesian grids

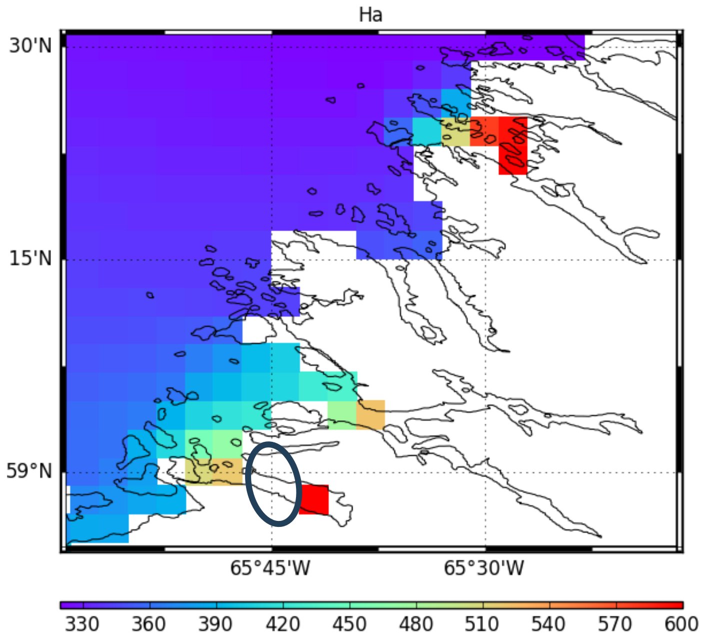
Strong differences are visible locally

If bathymetry is not accurate enough FE solution can have strong estimation error at the end of some narrow fjords

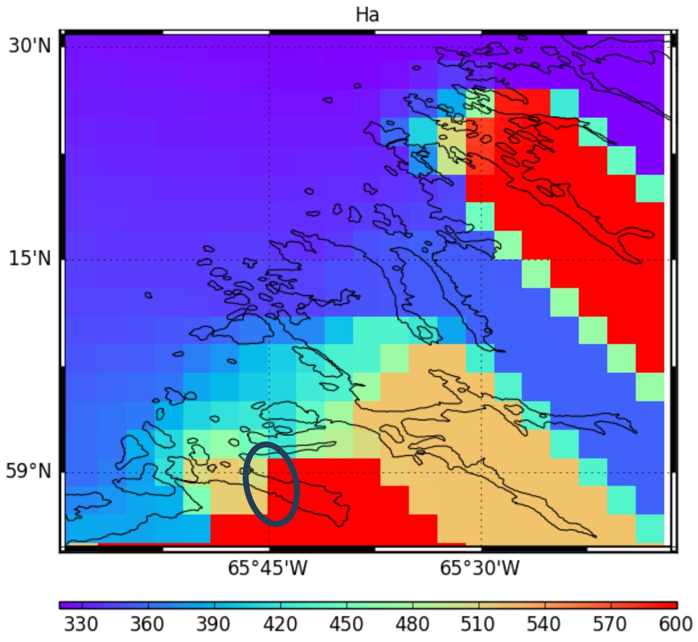
Extrapolated cartesian solution can smoothes this local phenomena

=> careful when analysing SLA in narrow fjords regions

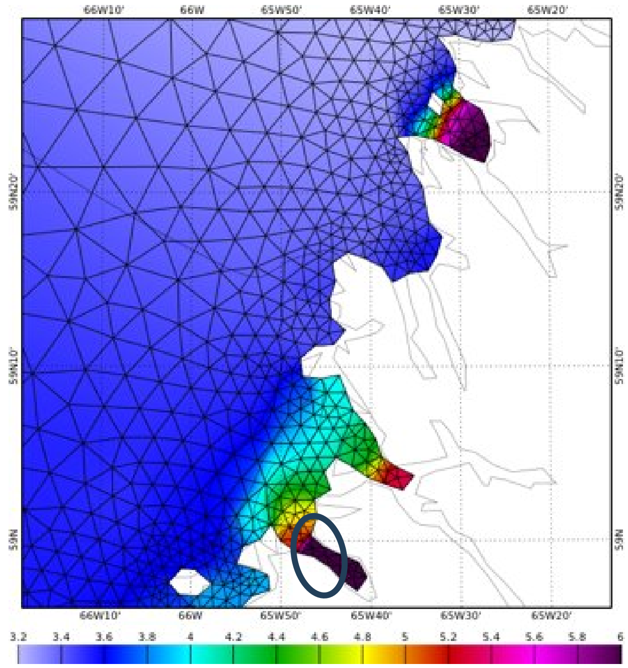
Example on a fjords region in the northern Quebec



Cartesian grid
Amplitude M2 (cm)



Extrapolated cartesian grid
Amplitude M2 (cm)

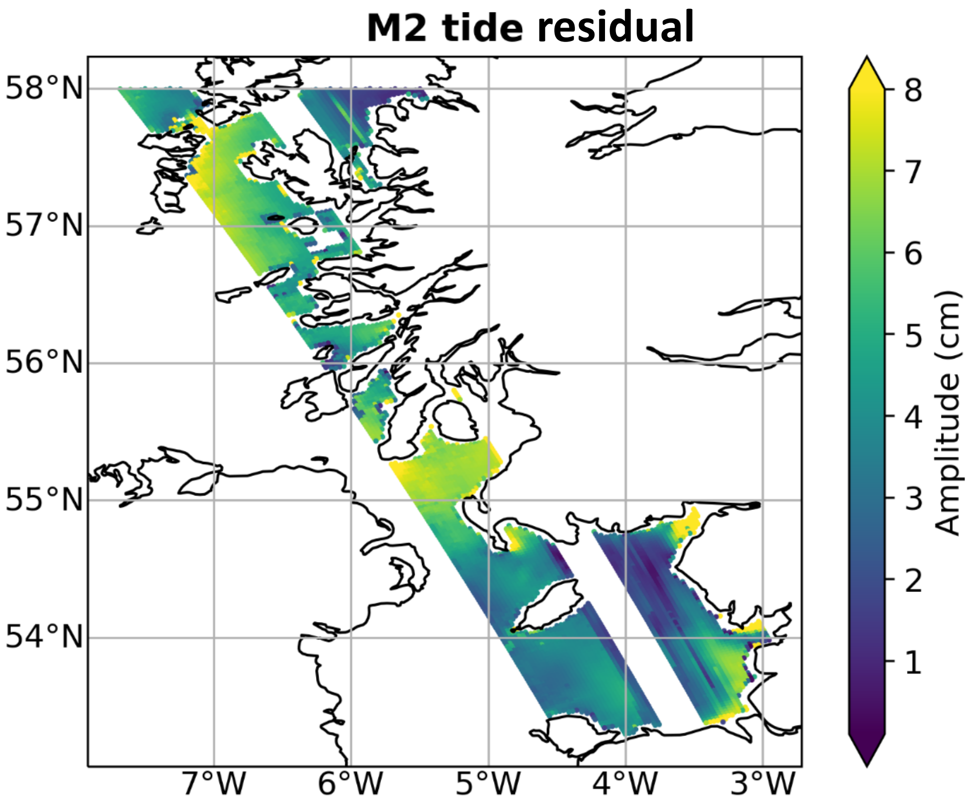


Finite Element grid
Amplitude M2 (m)

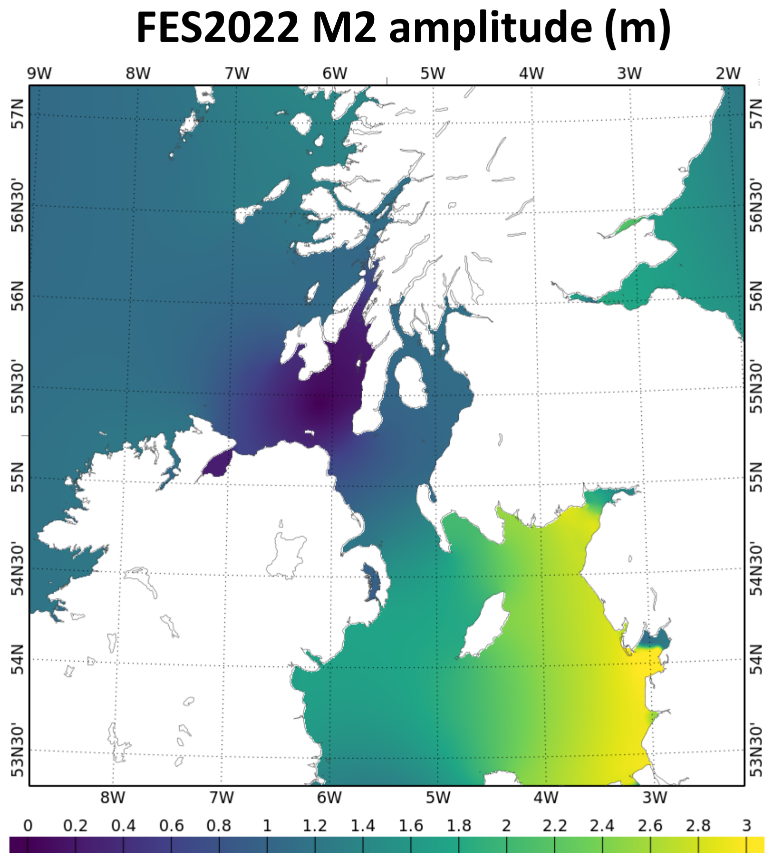
Harmonic Analysis of SWOT 1 day data

Some anomalies are detected likely due to remaining artefacts in L3 SWOT database

First tidal residual estimations from KaRin seems reasonable for M2 wave



KaRin L3 dataset => ssha_noiseless variable



Perspectives

FES2022:

- Model will be available on AVISO in early 2024
- Includes : tide elevations, loading tide elevations, tide currents and bathymetry + Libfes
- Pyfes available for experts via HPC/GECO (CNES)
- Regional analysis using 1day SWOT dataset
- On-going work on some waves (MSf, Sa, Mu2/2MS2)
- Already preparing the future evolutions of FES model : work on bathymetry and coastline ...

DAC:

- DAC-2days dataset will be available on AVISO in october 2023
- Investigate very HR SLEV/DAC variability visible in SWOT-1day data
- Higher temporal and spatial resolution for shelves/coastal seas ?
- Tests of tidal friction for surge simulation

Thanks for your attention !