Improving the geophysical corrections for altimeters and SWOT: tides and DAC

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Introduction

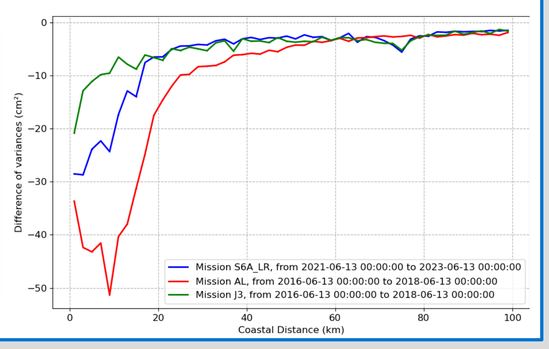
Altimeter measurements are corrected for several geophysical effects in order to isolate the oceanic variability. The tide correction is one of the most critical. The Dynamic Atmospheric Correction (DAC) is the second most important one after the tide correction. The accuracy of both tide and DAC models has been much improved over the last 30 years leading to centimetric accuracy in the open ocean and in some coastal areas.
To address the reduction of remaining errors in shelf/coastal seas and at high latitudes and to face the new challenges of the tide correction for HR altimetry, in particular the new SWOT mission, a new global tide model FES2022 has been developed recently and last validation diagnostics are presented here.
A new DAC version has been deployed in 2023 which improves the quality of the correction and a specific solution has been developed to address the specificities of the SWOT CalVal phase mission. Validation results and perspectives are presented in this poster.

FES2022

COASTAL VALIDATION

- Specific diagnostics focusing on coastal regions have been performed using several altimeter missions : J3, AL and S6A
- Results show strong improvement with FES2022 near the coasts, even greater for AL as it samples also high latitudes and Arctic shallow water regions
- Validation using IceSAT-2 data has also been investigated allowing going closer to the coastline (See presentation by Y. Faugère in Coastal Altimetry session on 09/11/2023).

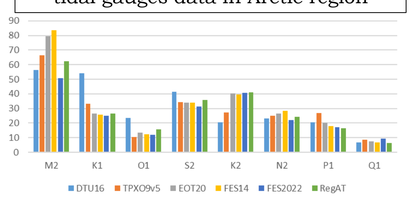
SLA variance difference when using FES2022 tide model instead of FES2014 as a function of coastal distance, for 3 missions, in cm².



Validation in POLAR REGIONS

- Comparison of FES2022 with tidal gauges data in Artic region : ArcTiCA database (TUM)
- FES2022 closer to observations than other models, except for O1 & Q1
- FES2022 also better than the regional solution RegAT (Noveltis)

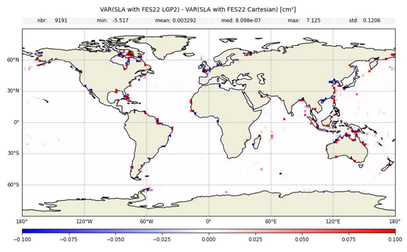
RMS (mm) of several tidal models vs tidal gauges data in Arctic region



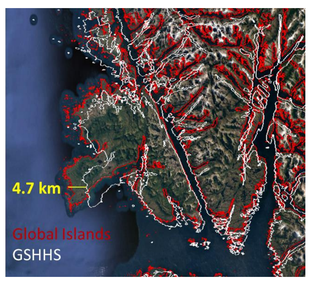
	DTU16	TPXO9v5	EOT20	FES14	FES2022	RegAT
RSS (mm)	99.1	95.0	105.8	108.2	82.7	93.5

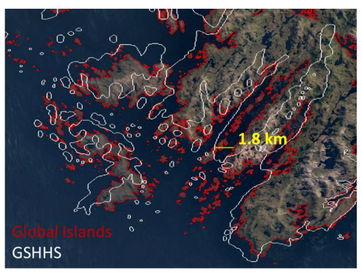
CARTESIAN & FINITE ELEMENT GRIDS

- We compare the performances of FES2022 cartesian grids 1/30° with the finite element LGP2 native grid resolution of the model
- Variance differences for J3 SLA is weak : +/-0.1 cm² locally with stronger differences on the coasts.
- There is no clear and systematic improvement when using LGP2 grids → need local investigations and likely improve the interpolation when outside the LGP2 grid

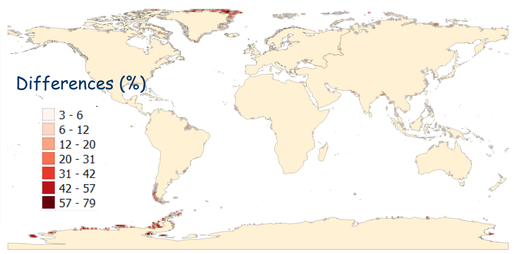


FES20XX - FUTURE EVOLUTIONS
Investigation of the coastlines databases
Comparison of GSHHS and Global Islands



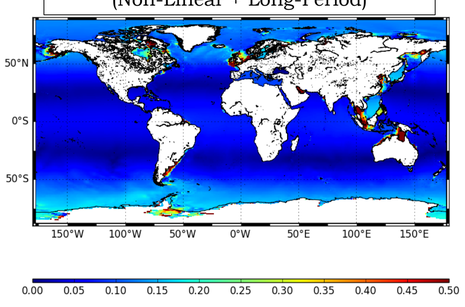


Surface differences between both coastlines on 1°x1° pixels, in % => detection of areas to improve in future versions

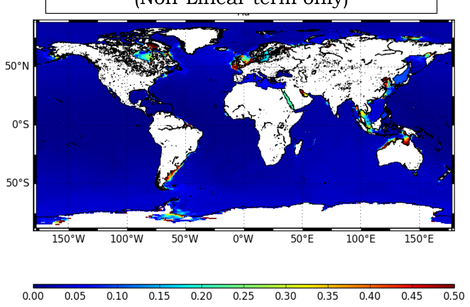


MSF FREQUENCY

Amplitude of MSF FES2022 (Non-Linear + Long-Period)

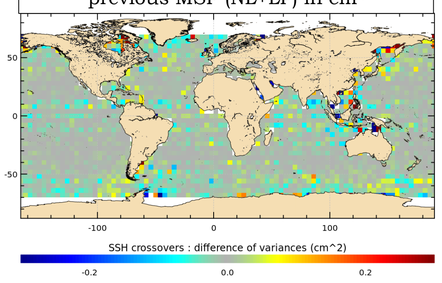


Amplitude of MSF_NL FES2022 (Non-Linear term only)



- FES2022 wave initially contained Non-Linear term + Long-Period Equilibrium variability
- Need to separate both components to adequately predict the tide with the libfes algorithm and for clarity
- Impact is positive on the resulting tide correction for altimetry => reduction of the J3 crossovers residual variance

Variance reduction of J3 crossovers when using the MSF_NL wave instead of previous MSF (NL+LP) in cm²



FES20XX - FUTURE EVOLUTIONS

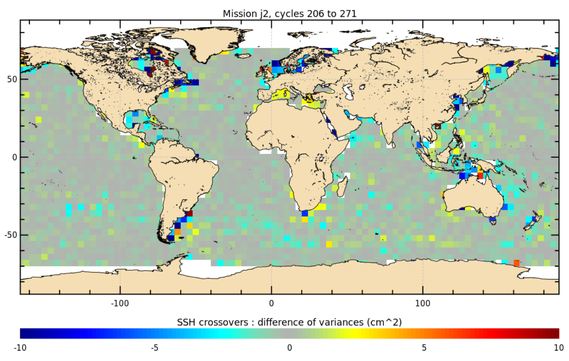
- **Investigate other coastlines data (OSM)**
- **Improve the local bathymetries**
- **Detect regions where local assimilation can be improved**
- **Investigate the use of SWOT data**

DAC

NEW DAC V4.0 :

- Available for DT/GDRs since 08/08/2023
- Includes several improvements :
  - **more accurate bathymetry field:** from FES2014 bathymetry
  - **Update of the barotropic model** version to fit TUGO model (Pineau-Guillou 2018)
  - **Improvement of the interpolation of atmospheric variables**

=> new DAC V4.0 solution reduces significantly the crossovers SSH variance on the global ocean compared to the operational DAC V3.5.1 : variance reduction can reach more than 5-10 cm² in coastal and shelf regions.

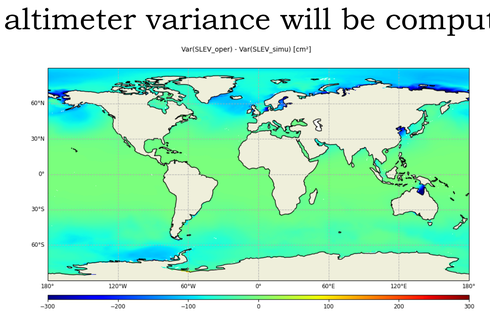


Variance difference when using the new DAC V4.0 solution instead of the operational DAC V3.5.1 solution, over 2 years of Jason-2 crossover data in cm2. Blue pixels indicate the improvement of new correction.

SURGE +TIDE simulations :

- A coupled simulation was performed on 6 years period
- Using ECMWF atmospheric forcing (pressure + wind) and gravitational forcing for main tidal waves
- Main challenge is to properly separate the tidal signals enhanced within the simulation due to both forcings and the non linear components of the simulation => harmonic analysis has been performed to estimate and remove the tidal waves
- Next step: performance analysis on altimeter variance will be computed

Variance difference of the high-frequency (T < 20 days) sea level computed by the operational DAC system and the coupled tide/surge simulation, over 8.5 years, in cm2.

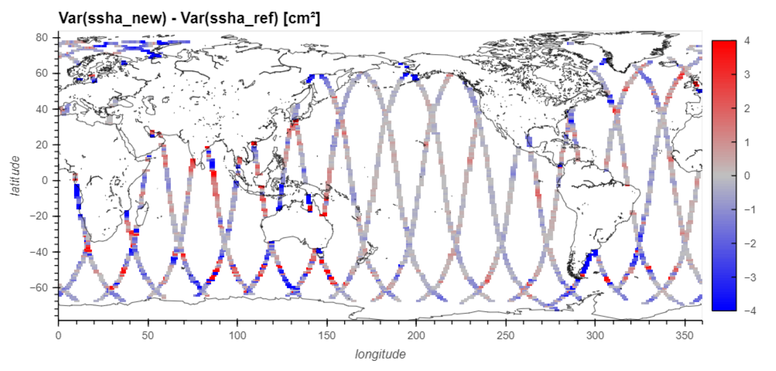


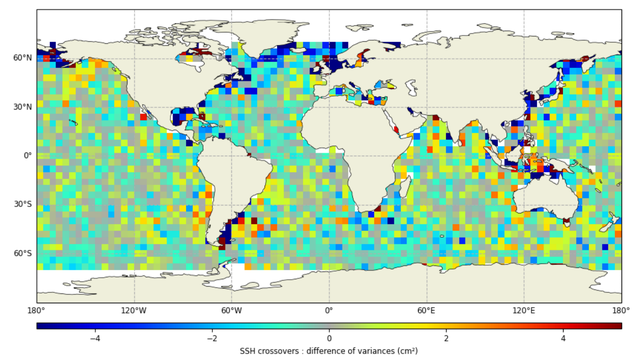
NEW DAC 2days :

- Specifically defined for SWOT CalVal phase products
- Available on SWOT CalVal phase period : 01/2023-07/2023
- Same processing chain as the operational DAC (V3.5.1) :
  - 6-hour ECMWF operational analysis for atmospheric forcing
  - S1S2 atmospheric pressure signal is removed from the forcing
- Uses a different filtering period to suit the SWOT CalVal phase 1 day sampling => uses a 2-days filtering cut-off to separate HF/LF in MOG2D and IB : **DAC_2days = MOG2D_HF2d + IB_LF2d**
- Filtered sea level grids are extrapolated on 2 pixels on the coasts to ensure a better coastal coverage (only 1 pixel for the operational DAC)

=> DAC_2days correction reduces significantly the 1-day SWOT nadir SLA on the global ocean compared to the static IB correction : variance reduction can reach more than 4 cm² in coastal and shelf regions.

Variance reduction of the 1-day SWOT Nadir SLA when using the SWOT CalVal phase specific DAC_2days) instead of the IB, in cm². Mean global variance reduction is -0.67 cm².





Variance reduction of Sentinel-6A SLA when using the DAC_2days correction instead of the IB, in cm².
Blue pixels indicate the improvement of the correction vs the IB; some yellow-red variability is visible due to the short period time-series

FUTURE IMPROVEMENTS of DAC

- **Improve mesh resolution and bathymetry → test FES2022 global parameters**
- **Improve model extrapolation on the coasts when computing the DAC**
- **Finalize the improvement of the bottom friction dissipation through the tide & surge coupled simulations**
- **Improve the S1S2 operational processing and check other waves that might be concerned (M2 ...)**
- **Use higher temporal resolution forcing and provide higher frequency model outputs (1h)**
- **Other perspectives include taking into account sea-ice effects and effects of waves on storm surges, and also the LSA effects.**