New FES2022 Tidal atlas

L. Carrere, F. Lyard, M. Cancet,
D. Allain, E. Fouchet, M. Dabat

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Introduction & context

The last release of the global tidal model FES2014b is distributed since mid-2016 & used in alti GDRs

FES2014b is characterized by :

- An increased unstructured mesh resolution in areas of interest like shallow waters and on the slope of the continental shelves
- Improved bathymetry in some regions
- The error of the pure hydrodynamic ocean solution has been divided by a factor of 2 compared to previous version (FES2004)
- But some errors still remain locally, due to uncertainties on compound tides and bathymetric errors (in shelf/coastal seas), seasonal sea ice effects and lack of available data for assimilation (in the high latitudes)

To address the reduction of these errors and face the new challenges of the tide correction for HR altimetry, in particular the forthcoming SWOT mission, the new project FES2022 has started in 2020.

The objective is to produce a more accurate global tidal solution, particularly for shallow waters and high latitudes.

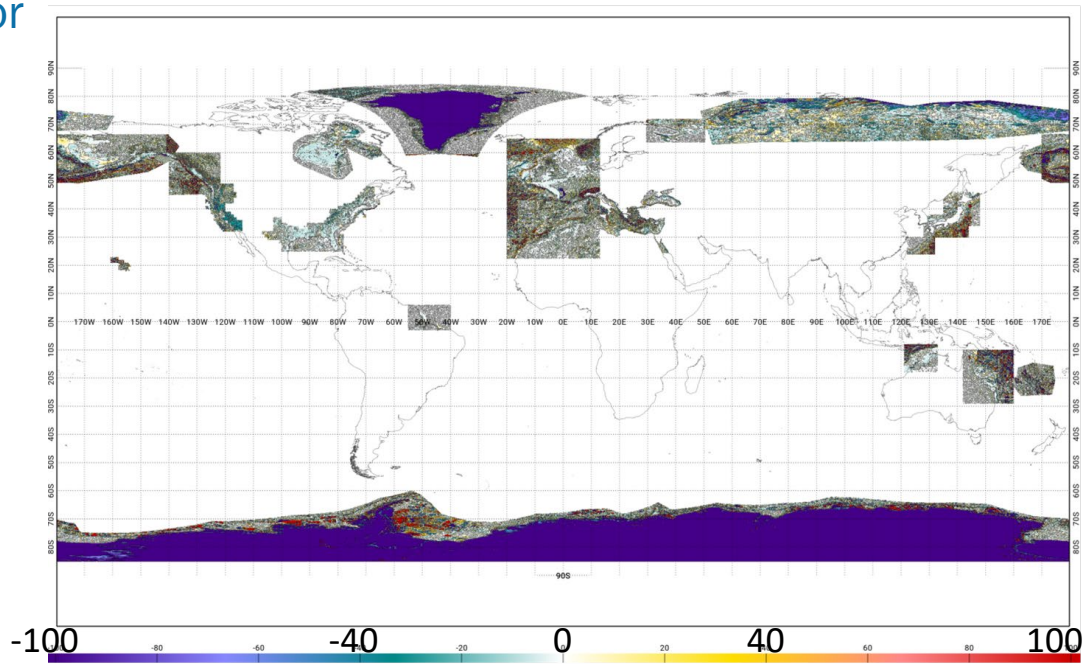
FES2022 new bathymetry

GEBCO 2020 database is taken as the reference bathymetry for FES2022

Methodology = combining many local or regional bathymetric databases collected (and/or re-processed) or developed within the framework of the Bathy-CNES project

We selected the bathymetry modifications that improve the overall accuracy of the test simulations (primarily for the M2 and K1 waves, and then for S2, N2, K2, O1 and Q1)

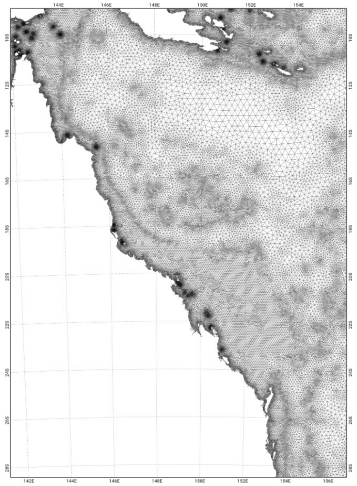
Thanks to all teams who provided some local bathymetry databases !

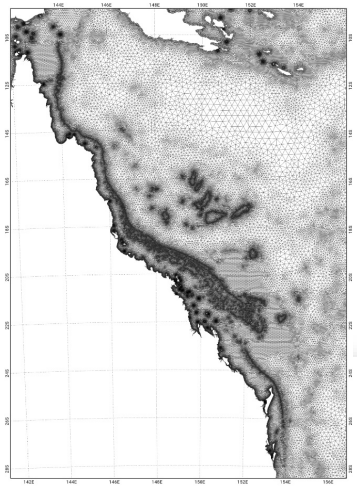


Difference between GEBCO 2020 and the FES2022 composite bathymetry (m)

FES2022 new HR mesh

Example on the Great Barrier Reef : initial FES2022 mesh, and then refined on the reef patterns





The generation standard values for FES2022 global mesh were set as follows:

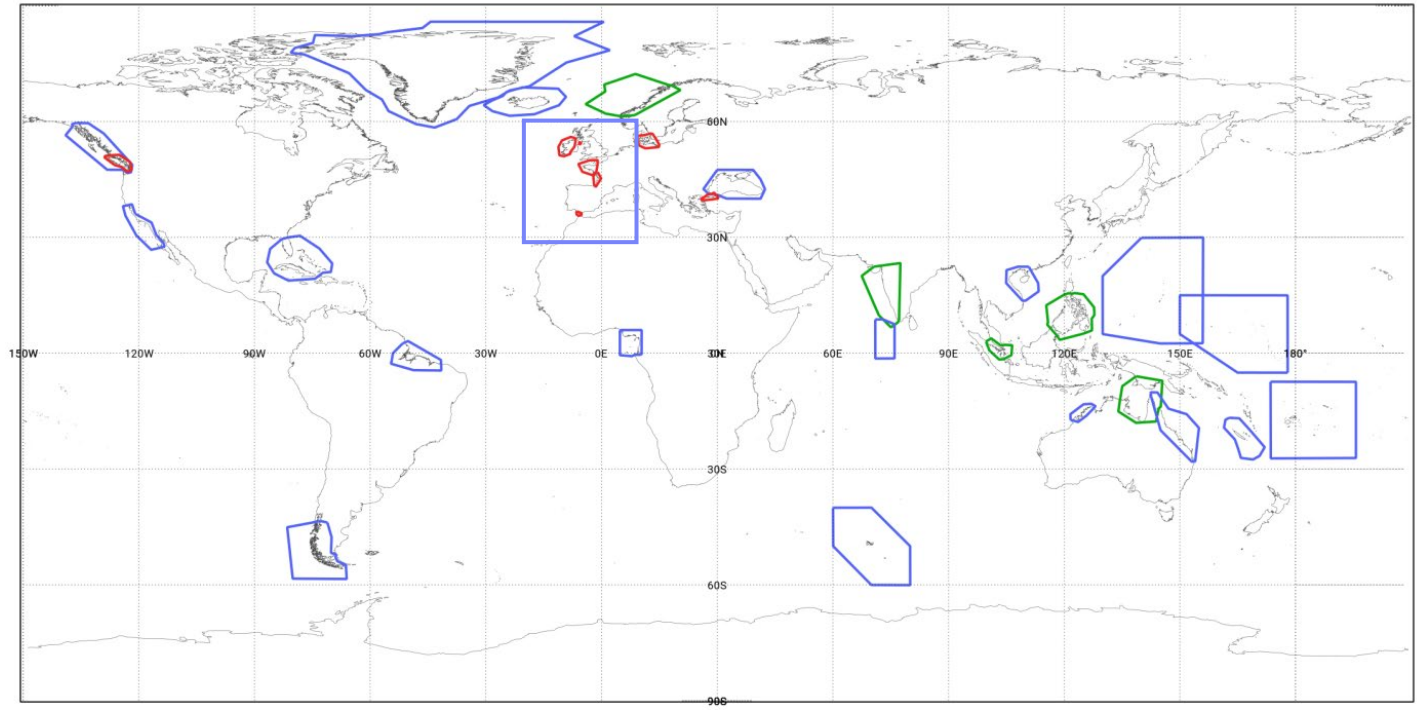
- Offshore resolution : 30 km
- Shelf resolution : 10 km
- Resolution at the continental slope : 6 km
- Coastal resolution: 4 km

Then a local/regional refinement stage was performed, guided by:

- coastline complexity (Norway, Tierra del Fuego, etc.)
- sensitivity of tidal modelling in certain critical areas
- local bathymetry accuracy
- the existence of scientific worksites (SWOT validation sites ...)

FES2022 mesh has about 11 000 000 elements = x8 more than the FES2014 grid

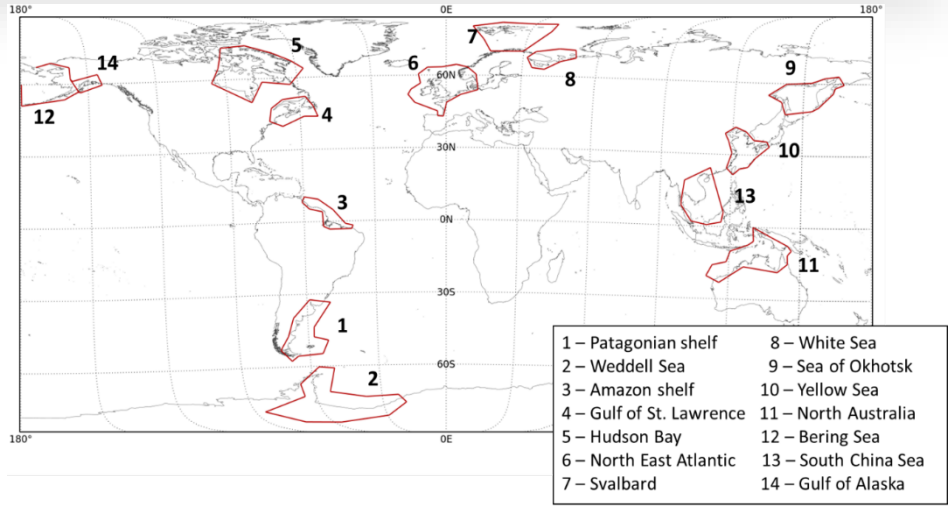
FES2022 new HR mesh



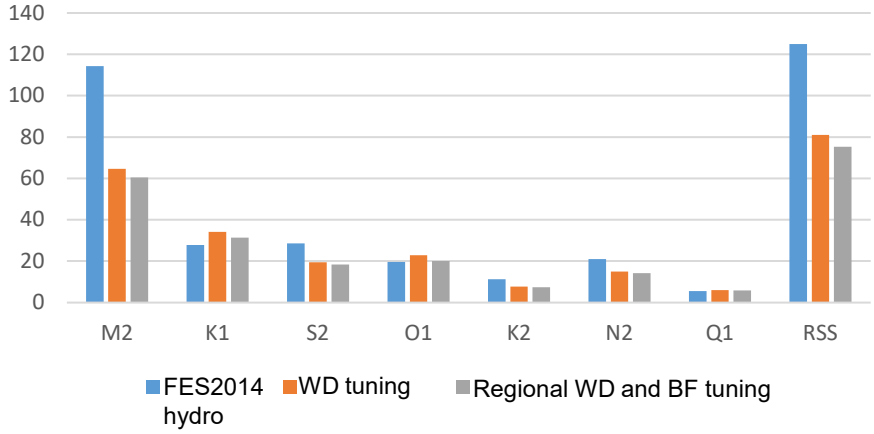
Coastal refinement areas: **3km (green), 2km (blue), 1km (red), 500m (magenta)**

Hydrodynamic solution

Fine tuning of different parameters : BF and wave-drag



Validation to shelf crossovers : vector difference (mm)



Regional tuning improves the global RSS to shelf xovers :

-9.2 mm compared to global tuning

-49 mm compared to FES2014 hydro.

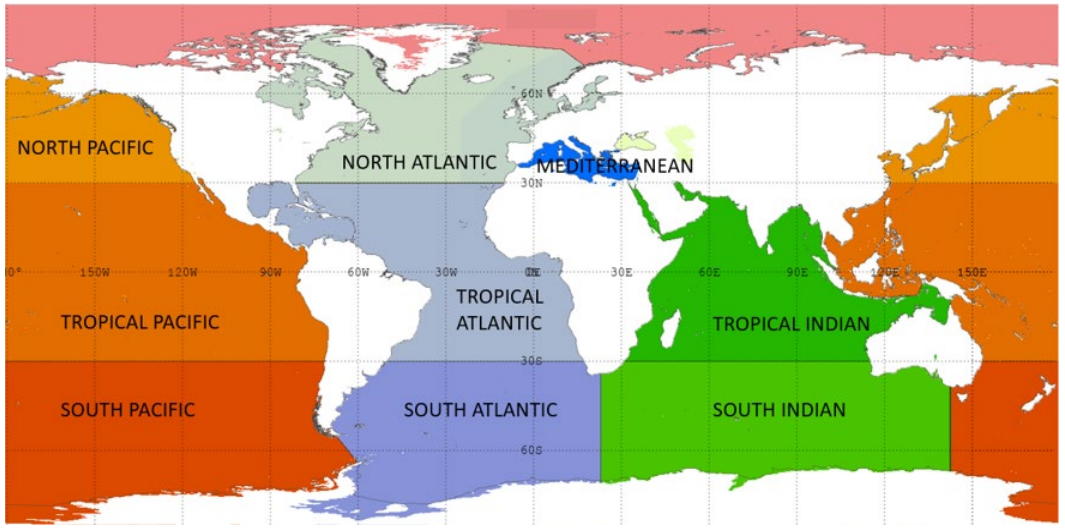
Regions where the BF has been tuned

New databases for assimilation

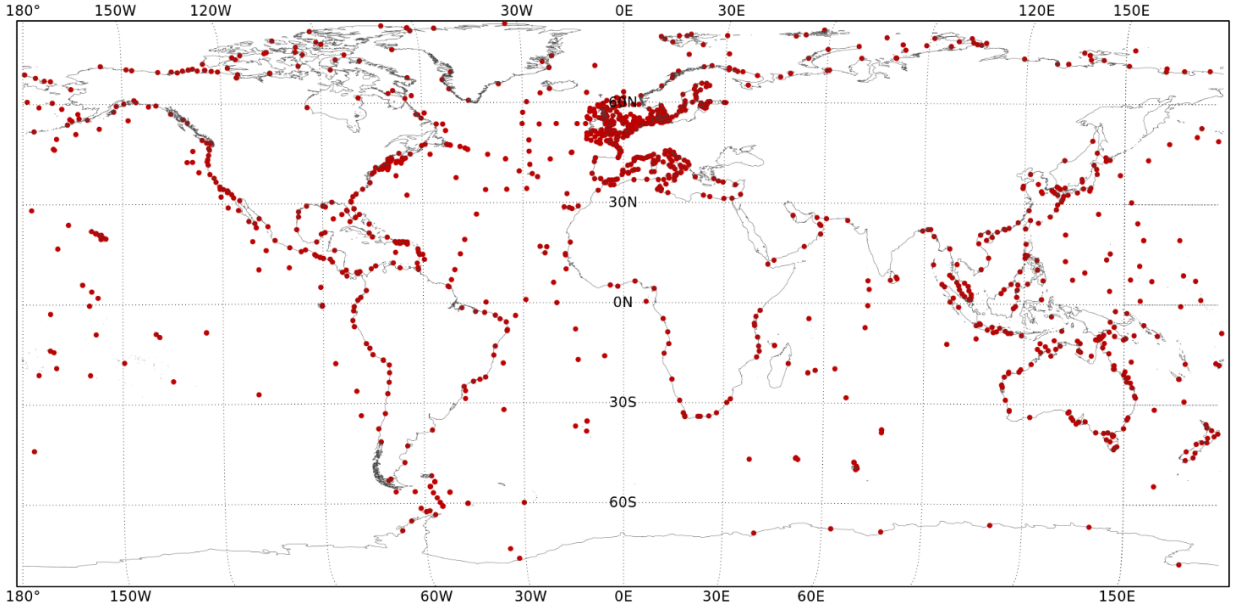
- Assimilation ensemble = 358 simulations
  - Perturbations of bottom friction / 11 regions
  - Perturbations of WD /oceanic basins
  - Perturbations of bathymetry / 19 regions

- Global TG database updated
- New altimeter database for global ocean and polar oceans

8 sub-basins used for the perturbation of the wave drag coefficient – Mediterranean Sea excluded



1220 TG included in the final database used for validation and/or assimilation



FES2022 altimeter database on global ocean - repetitive tracks

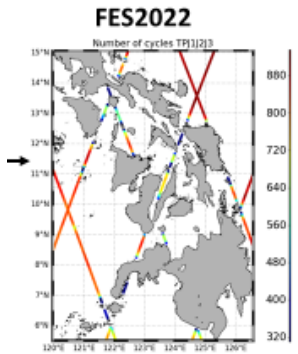
On the entire altimeter era : **TP-J1-J2-J3, TPN-J1N-J2N and ERS-EN-AL**

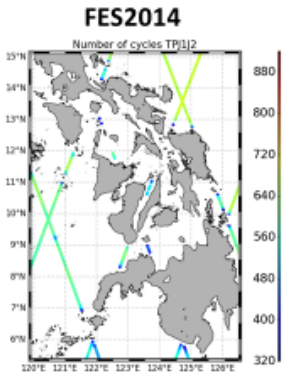
Includes new standards for instrumental and geophysical corrections (L2P 2021), including Zaron IT correction (2019)

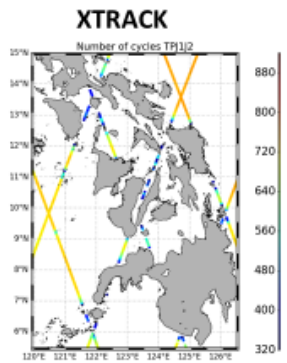
⇒ Better quality of the tidal estimations

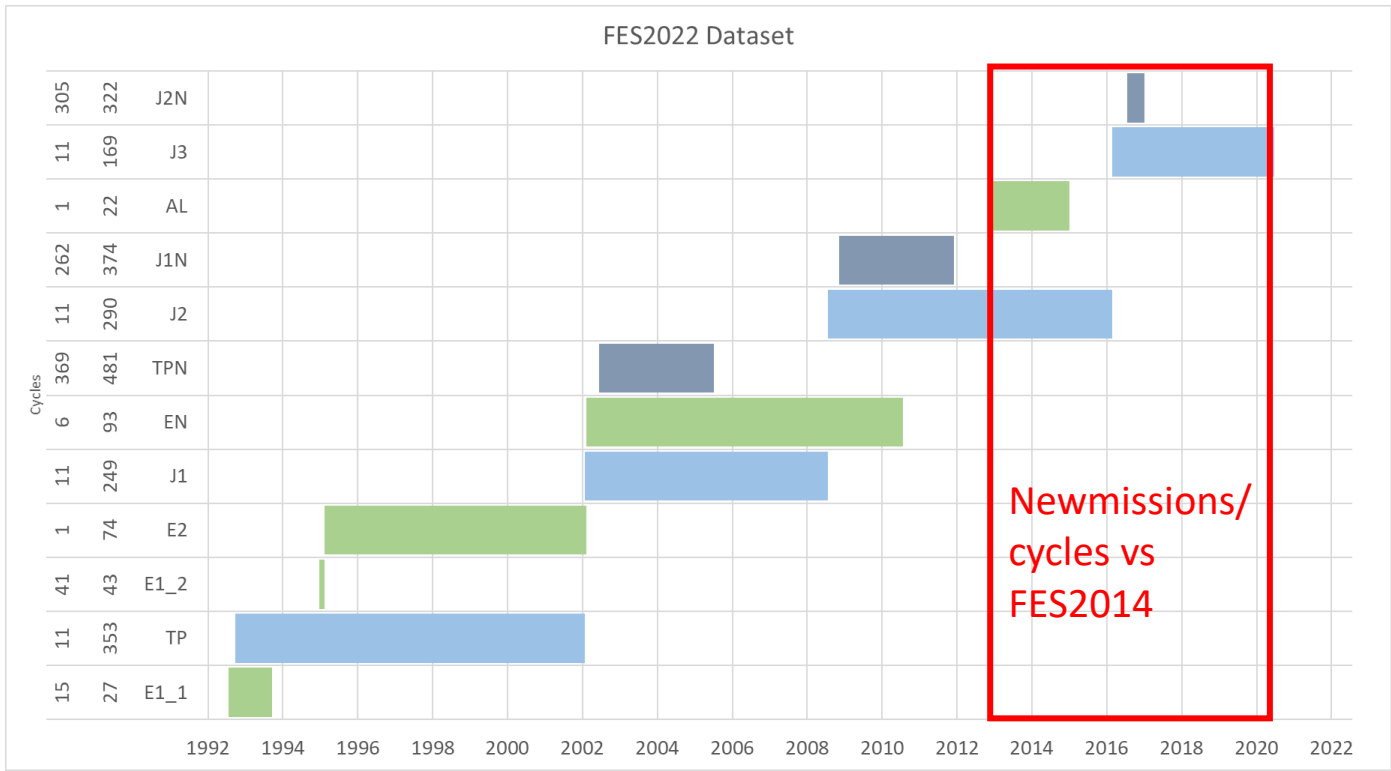
⇒ More points estimated

⇒ Get closer to the coast







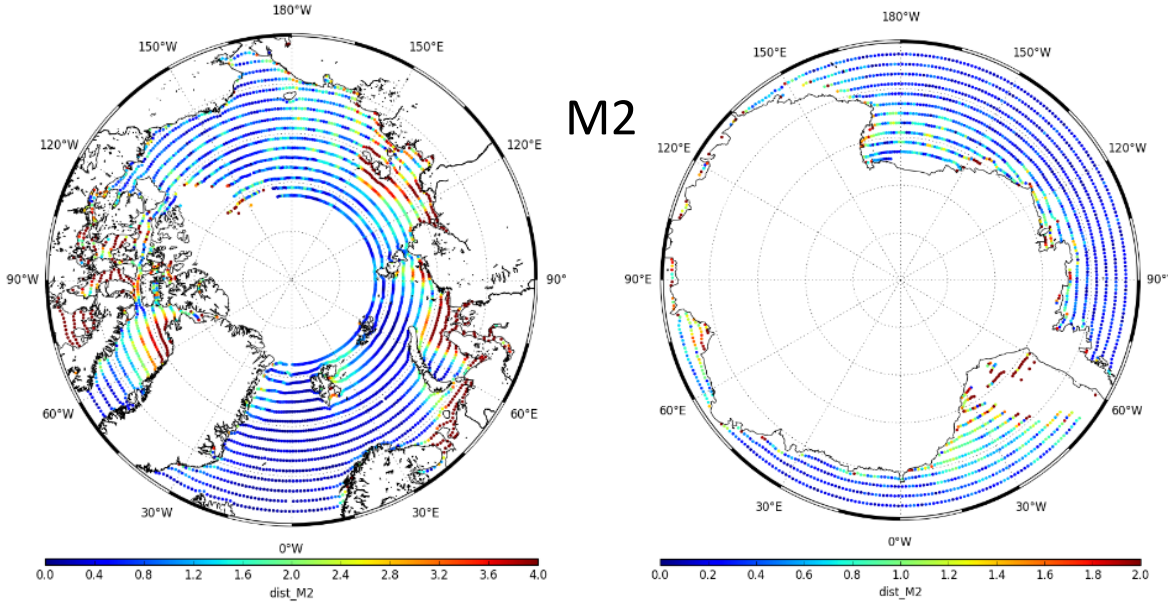


FES2022 altimeter database for polar regions

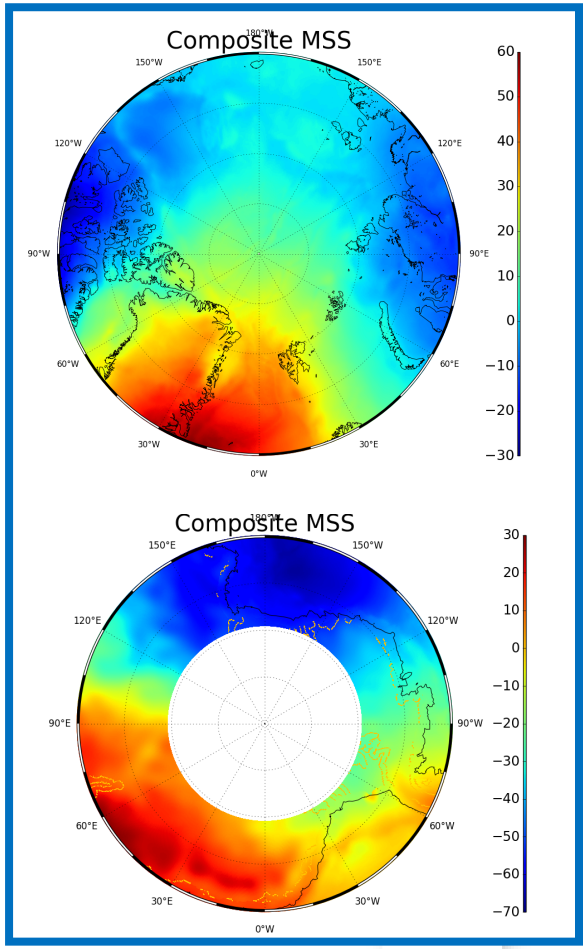
The reference missions are not available in these regions. => **construction of a specific database for |LAT| > 66° using all available altimeter missions combined in small boxes**

- Same corrections/processing as the **L2P 1Hz** database used on the global ocean
- Use the composite MSS for drifting orbits + recent missions and PM for repetitive tracks

Observed tide – FES2014 (cm)



Composite MSS = mix of SCRIPPS, CNES15, DTU15



Assimilated solution FES2022A

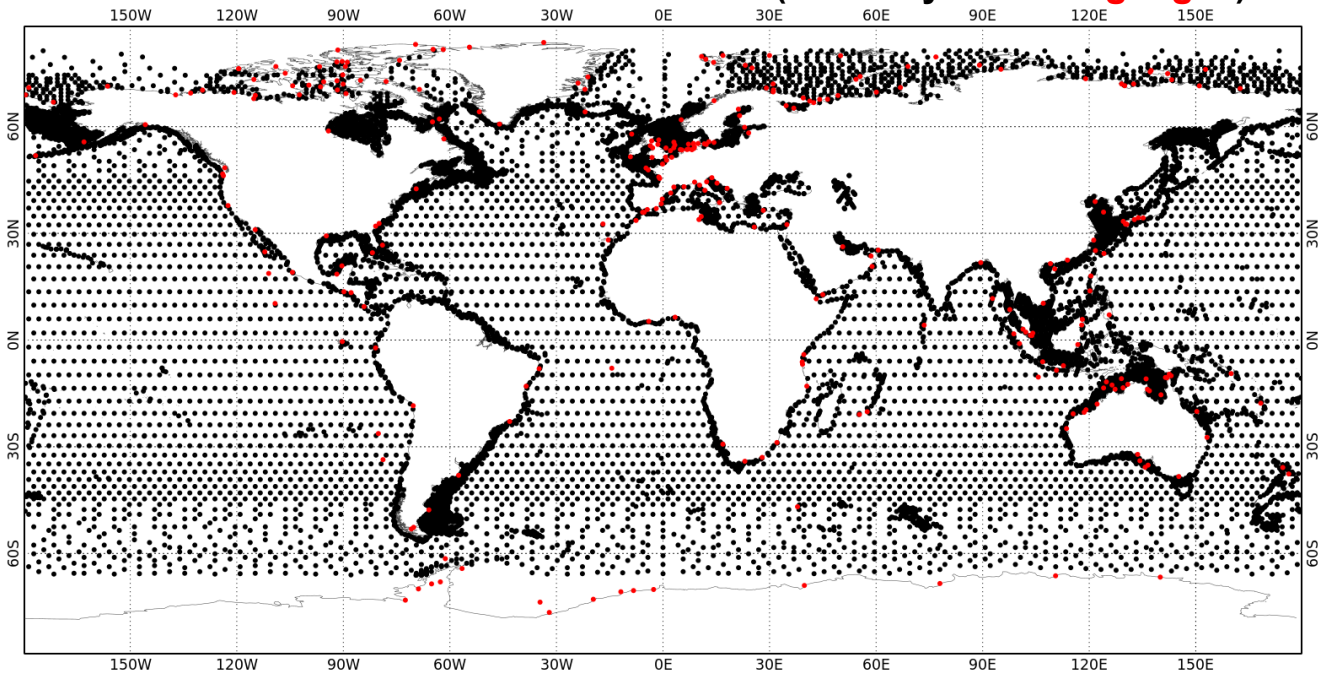
16 waves assimilated => 2N2, E2, K1, K2, L2, La2, M2, Mu2, N2, Nu2, O1, P1, Q1, S2, M4, J1

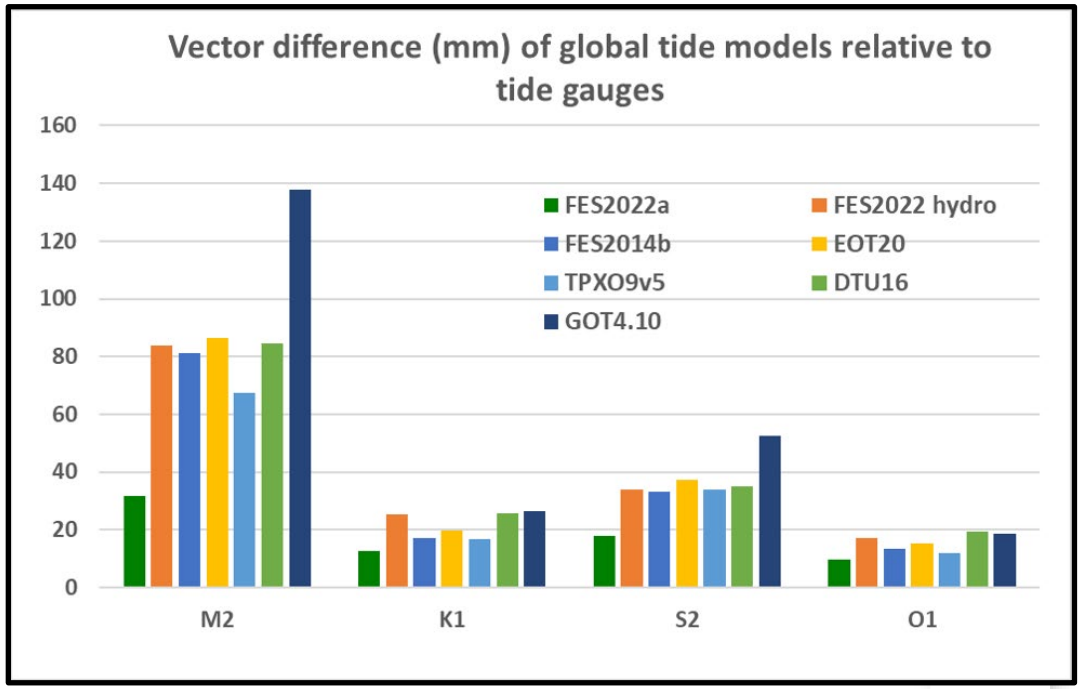
FES2014 waves to complete spectrum => 34 waves in FES2022A atlas

2 min x 2 min grid resolution

Assimilated data	FES2014b	FES2022A
Altimetry points	12 022	13 489
Tide gauges	600	295

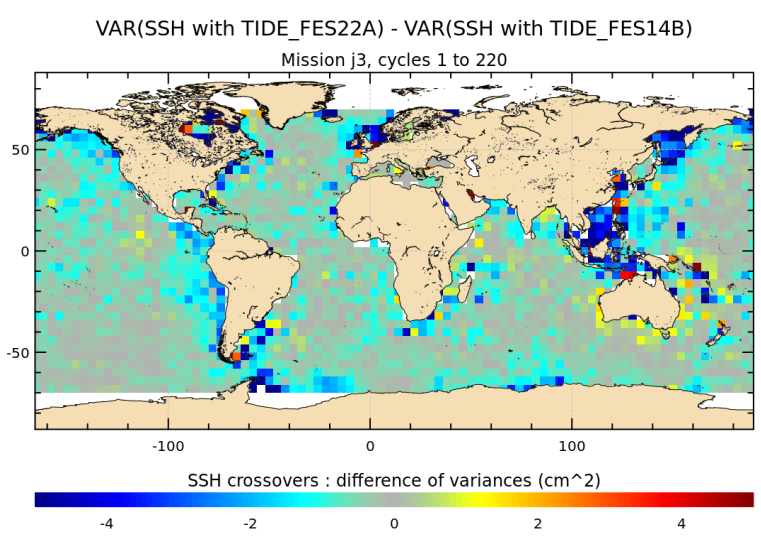
Assimilated observations in FES2022A (altimetry and tide gauges)

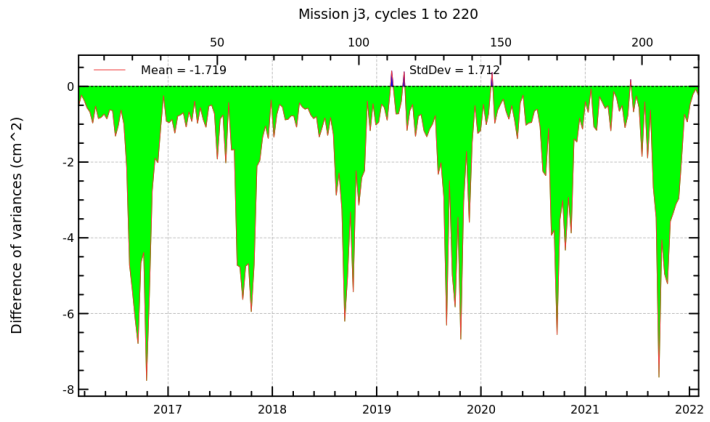




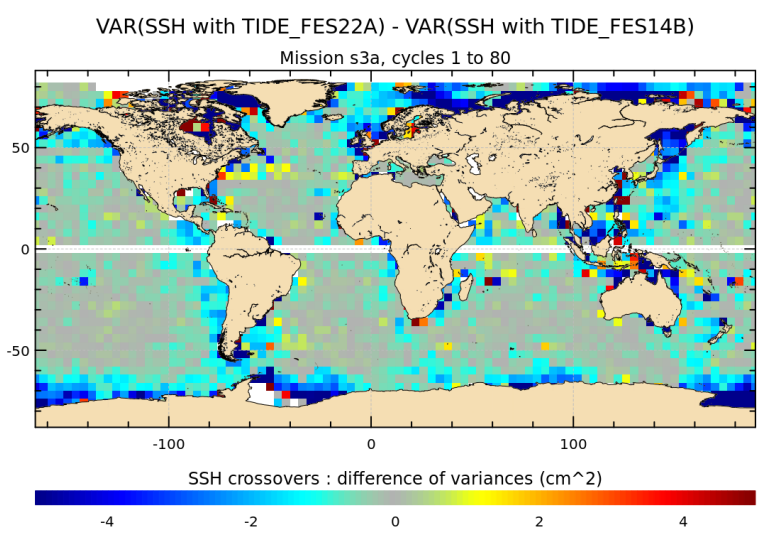
Validation results of FES2022A atlas vs FES2014

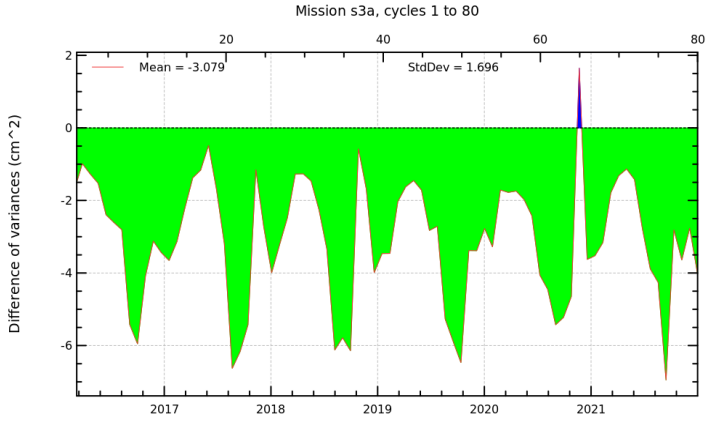
XOVERS J3



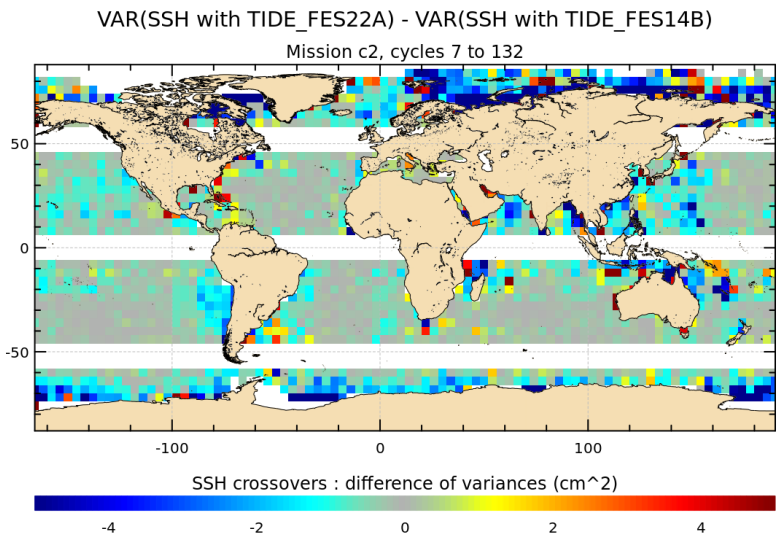


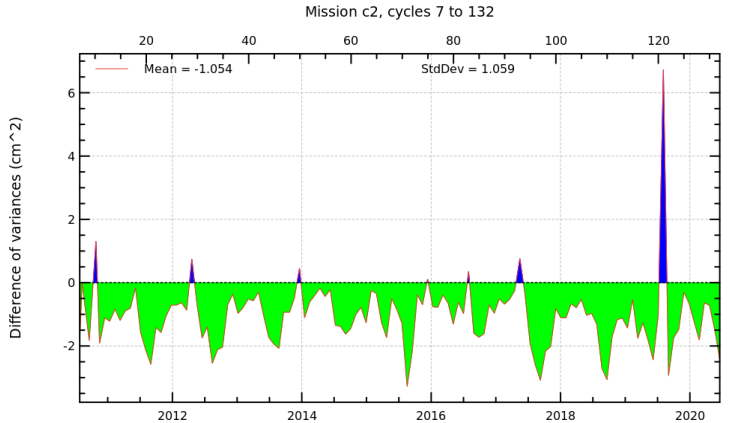
XOVERS S3A





XOVERS C2

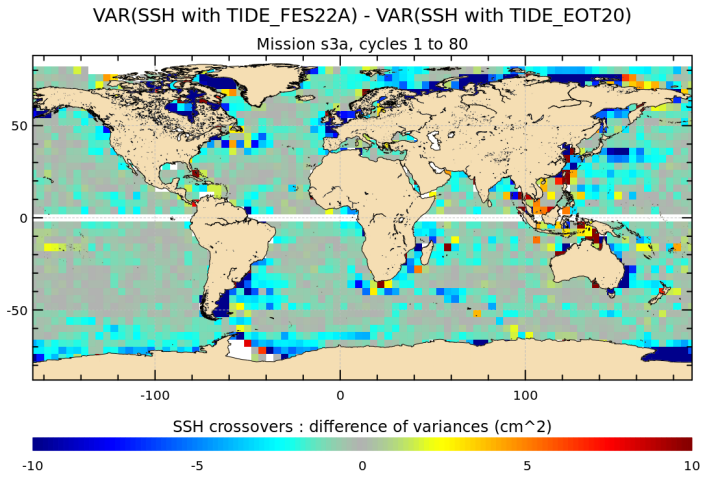


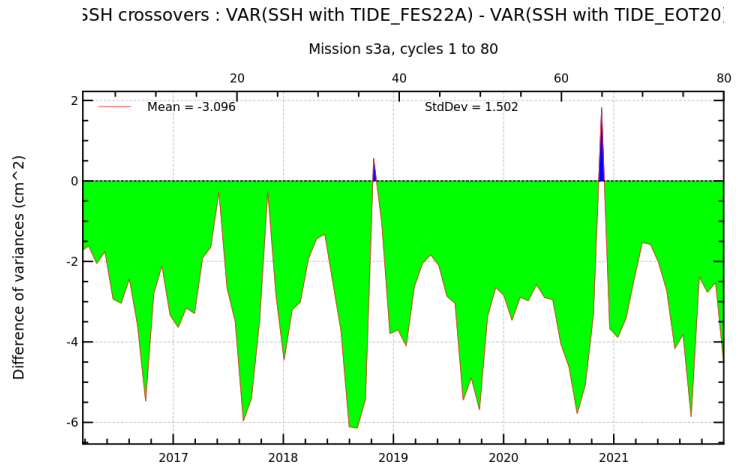


Validation results of FES2022A atlas vs other models

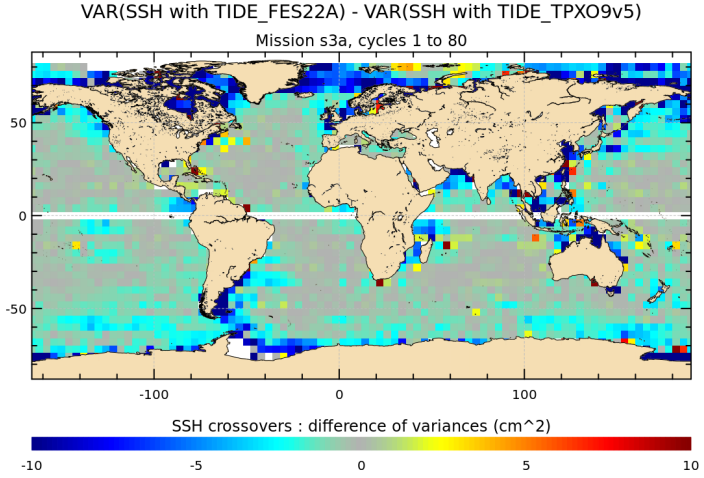
XOVERS S3A

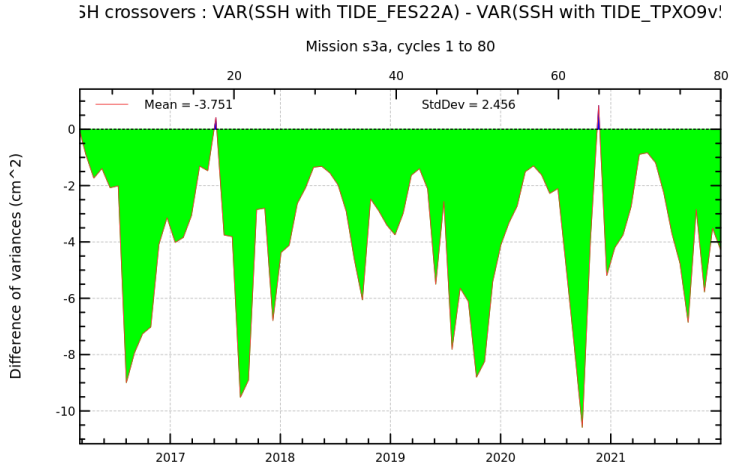
EOT20 -> all EOT20 waves but no Sa and SSa waves



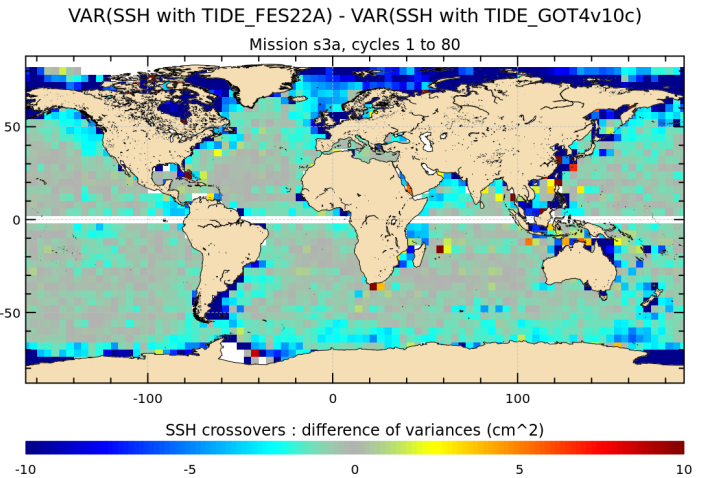


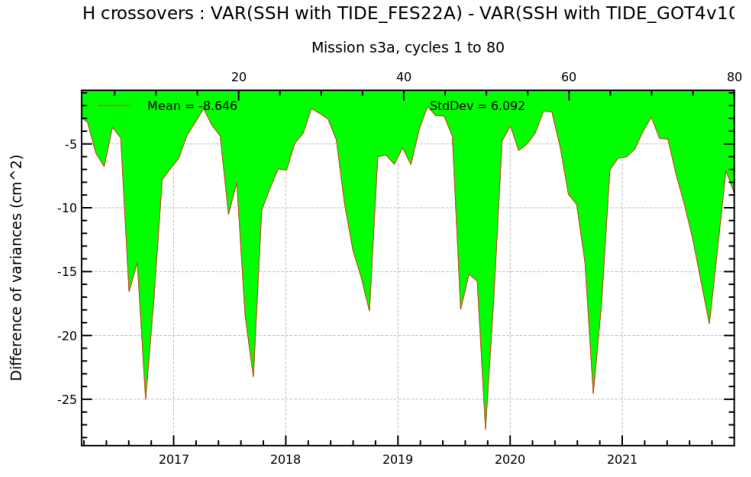
TPXO9.v5 -> all TPXO9v5 waves





GOT4.v10c -> all GOT4.10 waves





FES2022B tidal atlas

FES2022 loading tide has been computed on the FE grid => new computation code developed

New FES2022B hydrodynamic solution has been computed

Altimeter database has been updated to take into account this new LT

Assimilation of FES2022B atlas is on-going on HAL

⇒ Final version of FES2022B should be finished by the end of June.

⇒ FES2022B currents will also be computed

Conclusion & perspectives

New FES2022A tidal atlas has been computed and validation shows significant improvement compared to FES2014B and other models

Computation of FES2022B is on-going and shall be finished soon => even more improvement expected

Tidal currents will be computed also

Validation of FES2022B atlas planned this summer

FES2022B atlas should be released in November 2022

OSTST and SWOT tidal groups can have access to the atlas on demand for early assessment

34 waves on 2min x 2 min grid

Grids extrapolated on the coasts should also be available, in addition to non-extrapolated grids