

FES 2014 : a new global tidal model

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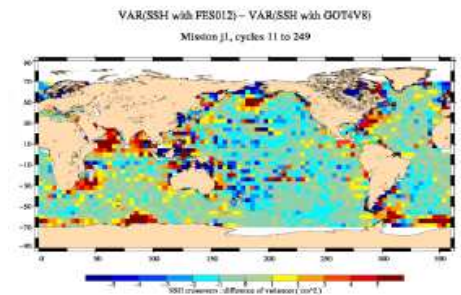
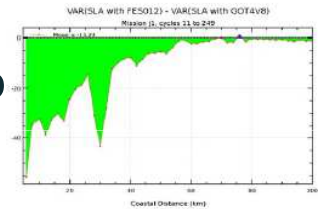


OST/ST 2015

October 20-23, 2015
Reston, VA

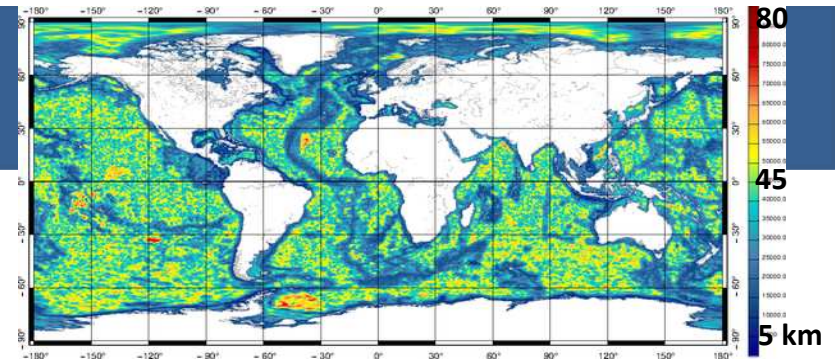
Introduction

- Accuracy of tidal models has been much improved these last 20 years, but errors remain in shallow waters and high latitudes
- Still need to improve tide correction for all altimeter missions, particularly for future SWOT mission and HR altimeters
- In 2012, we have developed a new high resolution tidal model on global ocean
 - FES2012 results are good in shallow waters + coastal regions altho TG has been assimilated (cf Stammer et al. 2014)
 - But altimeter crossover variance is raised in some places
- => New release FES2014 has been performed in order to improve FES2012 results in deep ocean, at high latitudes and in shallow/coastal regions



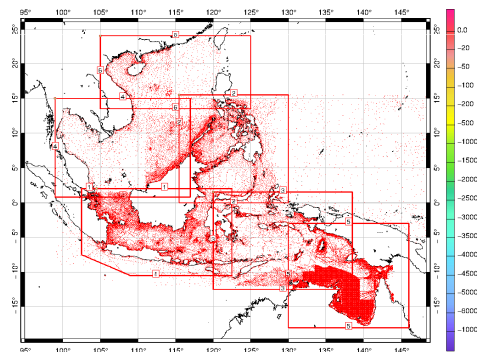
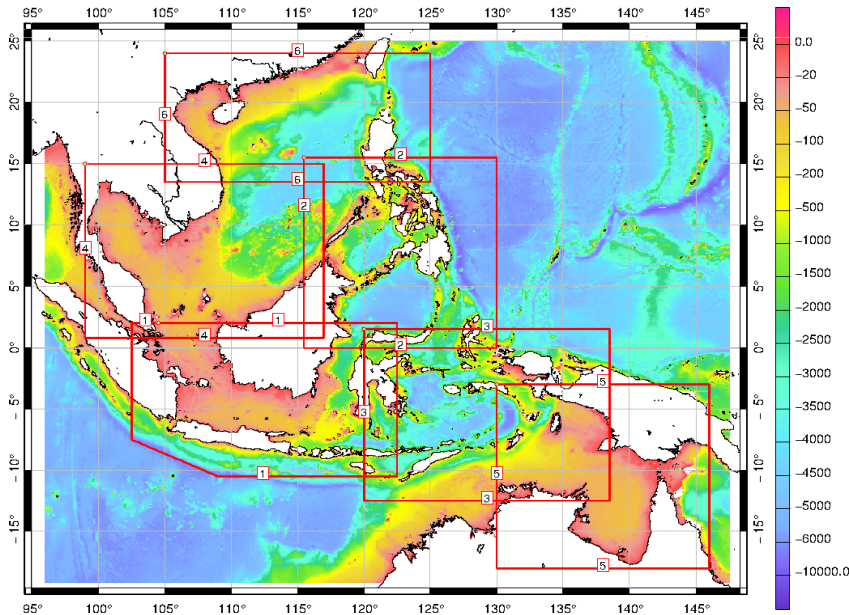
FES2014

- FES2014 benefits from:
 - Better hydrodynamic modeling including better bathymetry and refined mesh



FES2014

- 1 464 500 triangles
- 2 981 213 elevation nodes
- 4 393 500 velocity nodes



- In situ data, nautical charts, adding SRTM elevation
- Merging with global database

FES2014 hydrodyn

FES2012 hydro

M2 RMS (TP/J1/J2 crossovers)

Deep ocean 2,5 cm

Shelf seas 9,3 cm

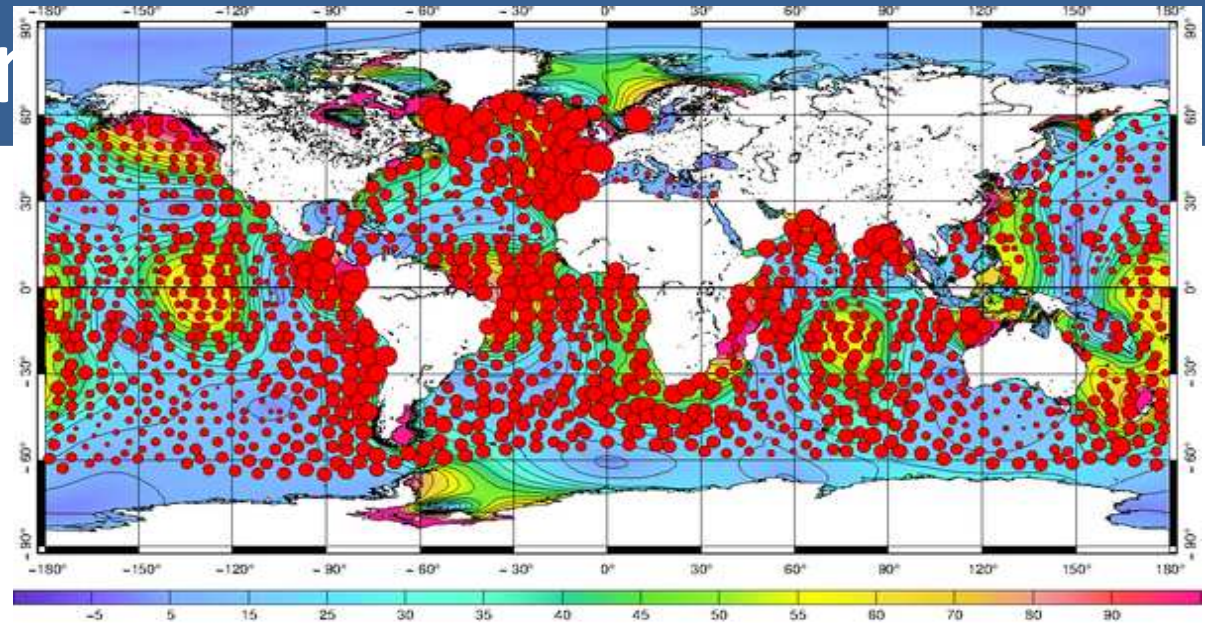
FES2014 hydro

M2 RMS (TP/J1/J2 crossovers)

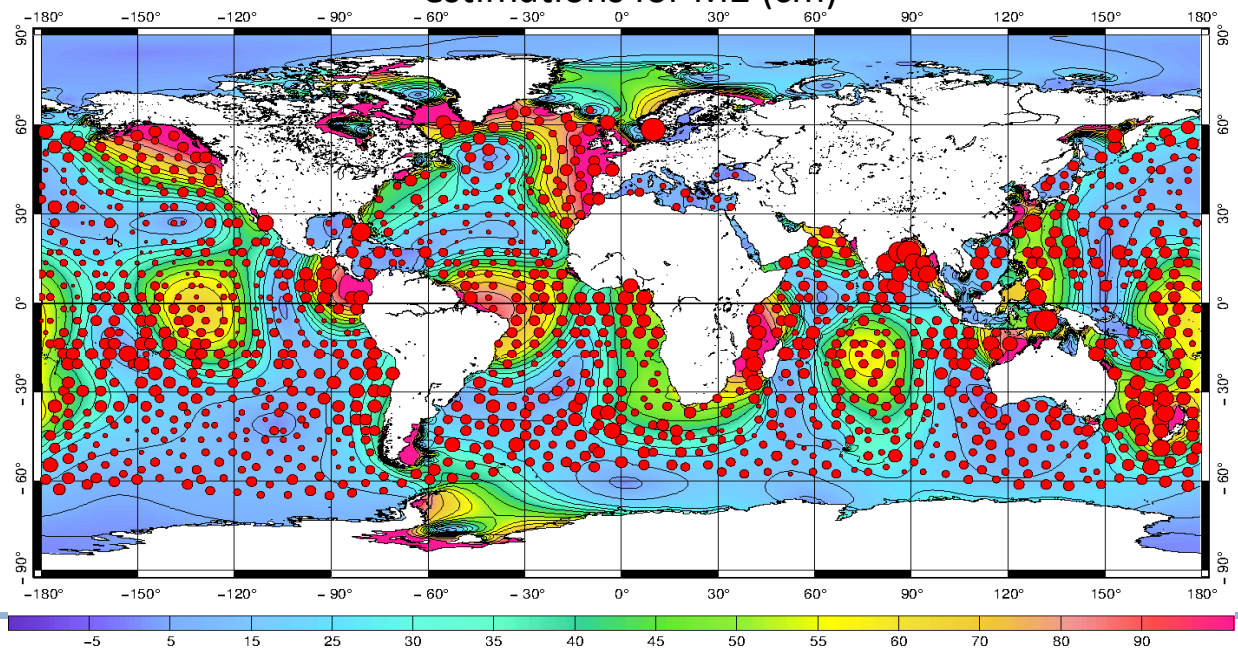
Deep ocean 1,20 cm

Shelf seas 5,37 cm

10cm



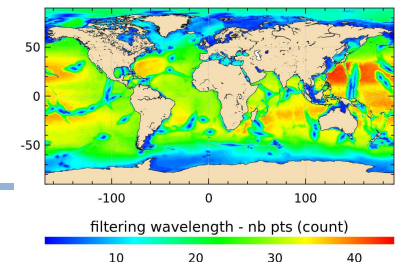
RMS between model and TPJ1J2 crossovers estimations for M2 (cm)



•2mm •5mm •1cm •2cm •10cm

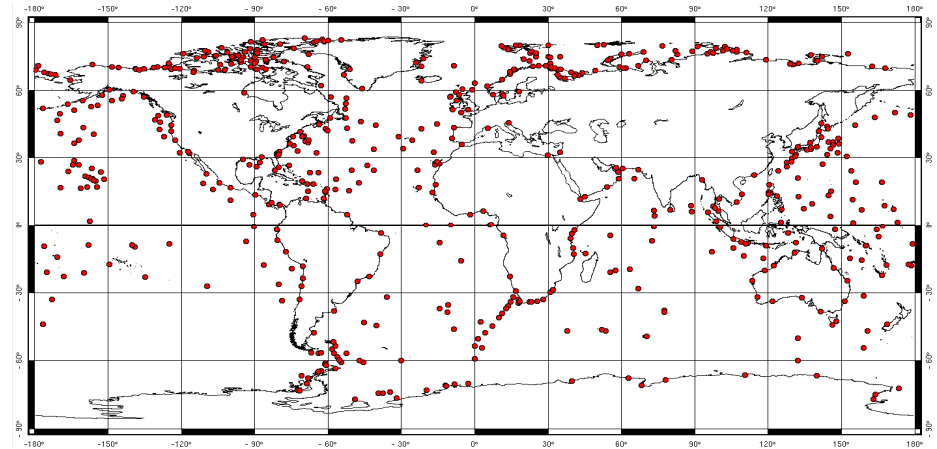
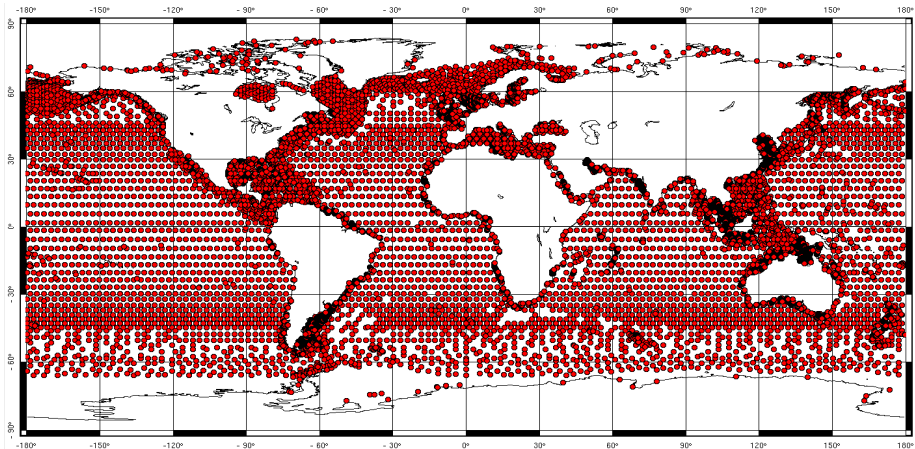
Assimilation: altimetry database

- 20 years time series for TP/J1/J2 nominal track => most of the alias issues have vanished
- 6y of T/P-J1 interleaved mission and 17y of ERS-EN missions => still some aliasing issues
- Reprocessed DUACS DT multimissions datasets have been used
 - Most recent L2 standards (DAC based on ERA-interim, GDR-D orbits)
 - Revisited L3 standards (editing, multimissions cross-calibration correction for ERS-EN missions)
 - **GOT4.8ac** tidal loading effects are used (**including tidal geocenter correction, R. Ray**)
- Harmonic analysis has been improved
 - **To take into account the effect of seasonal ice cover => strong improvement at HL**
 - Use GLORYS2-V1 to remove non tidal annual & semi-annual contaminations (TPNJ1N, ERSEN)
 - Improved along-track filtering to remove internal tide signatures



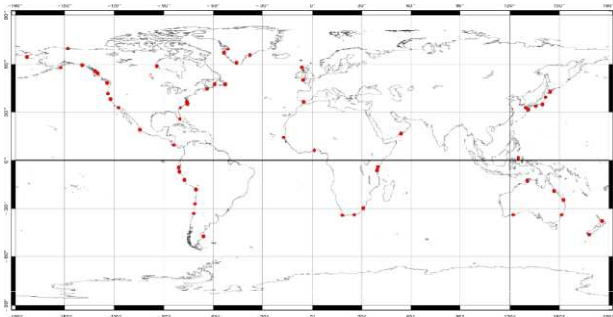
Assimilation

- **Spectral data assimilation code (SpEnOI)**
 - Ensemble method within representers approach: perturbations on bathymetry, friction coefficient, wave drag coefficient, minimum bathymetry value, loading effects (=> ~900 members)
- **Altimetry and TG data**
 - 12 622 assimilated points for M2, included 600 TG

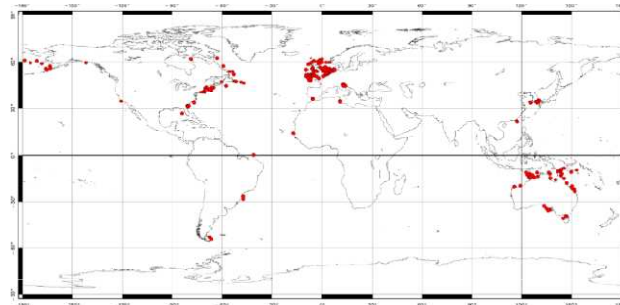


Spectral validation

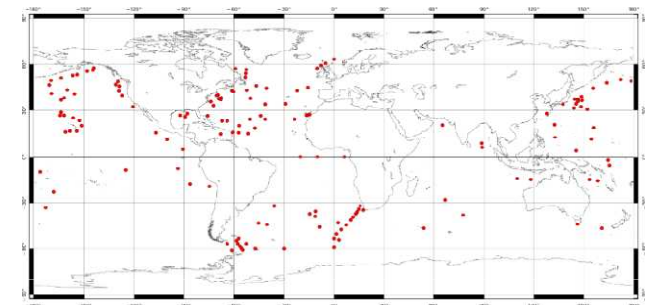
- Deep, Shallow, Coastal TG databases used in Stammer et al. paper (2014)



Coastal

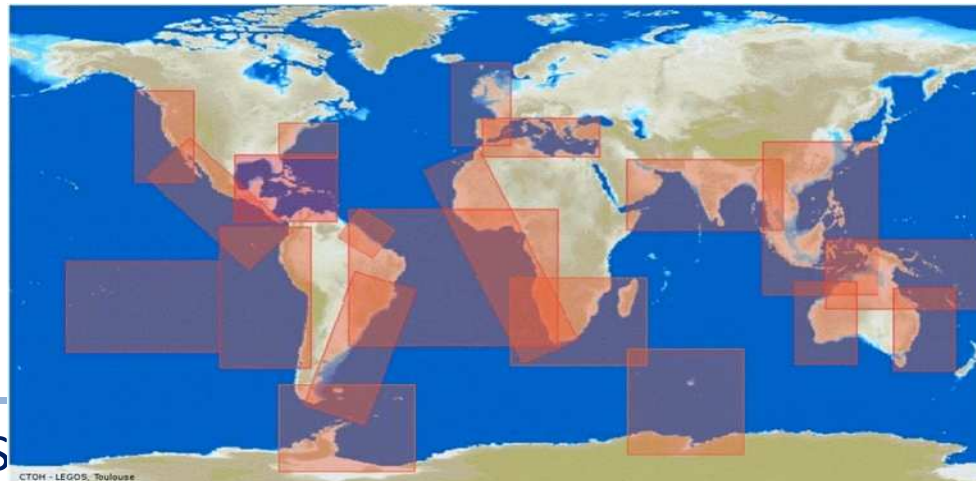


Shallow

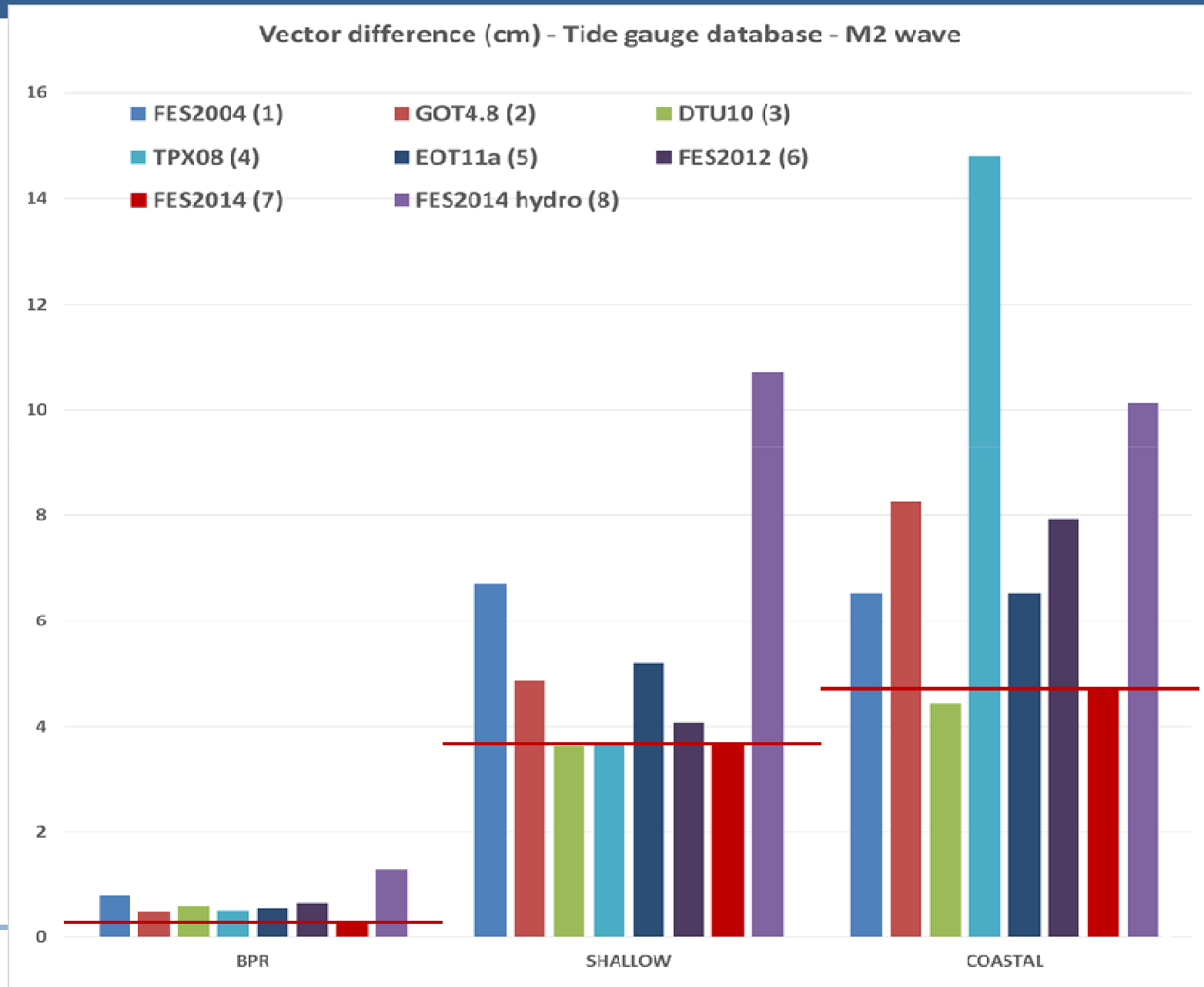


Deep BPR

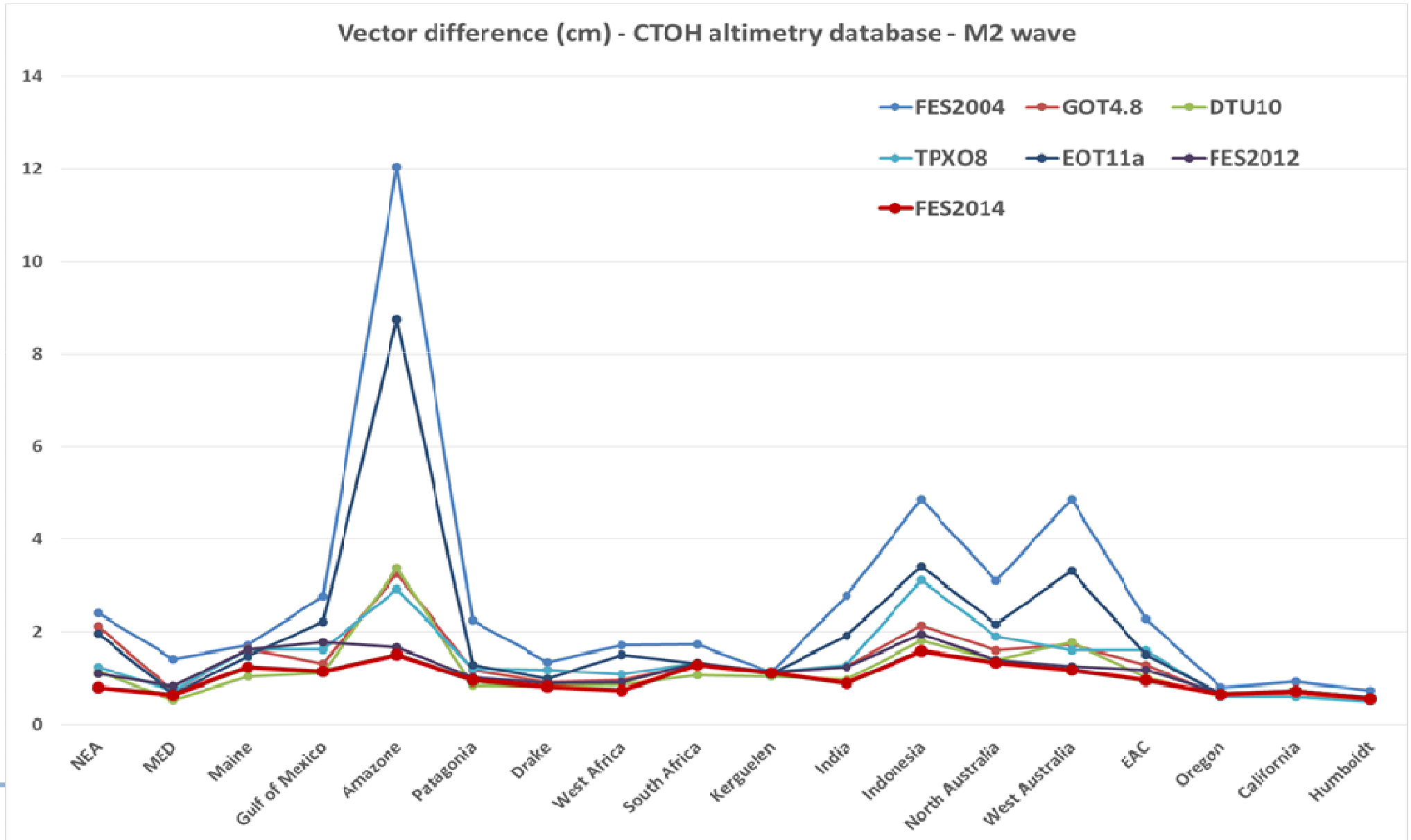
- Altimeter tidal constituents (CTOH) : <http://ctoh.legos.obs-mip.fr/products/coastal-products/>



Spectral validation - TG



Spectral validation - altimetry

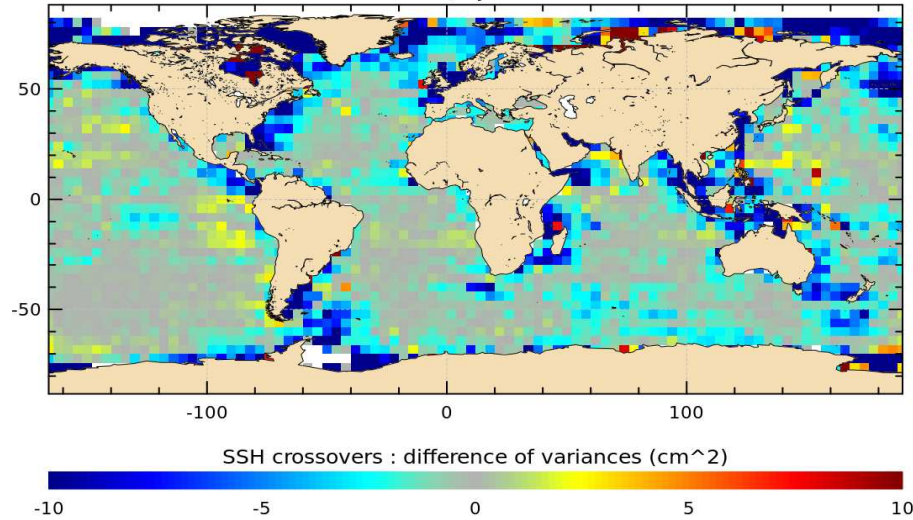


Temporal validation

- Modeling and omission errors
- **FES2014 final atlas**
 - **34 waves available**
 - **15 assimilated: M2, M4, S2, 2N2, K2, N2, K1, O1, P1, Q1, Mu2, Nu2, E2, La2, M4**
 - **9 non-linear + 6 long-period**
- Performances estimated versus TG databases + global altimetry databases (CLS/CALVAL)
 - Several years of **Jason-1, ENVISAT, ALTIKA, CRYOSAT-2**
 - Variance reduction analysis at crossovers **compared to FES2012, DTU10, TPXO8 and GOT4v8-v10 tide models**

VAR(SSH with FES2014NEWComple) - VAR(SSH with FES2012)

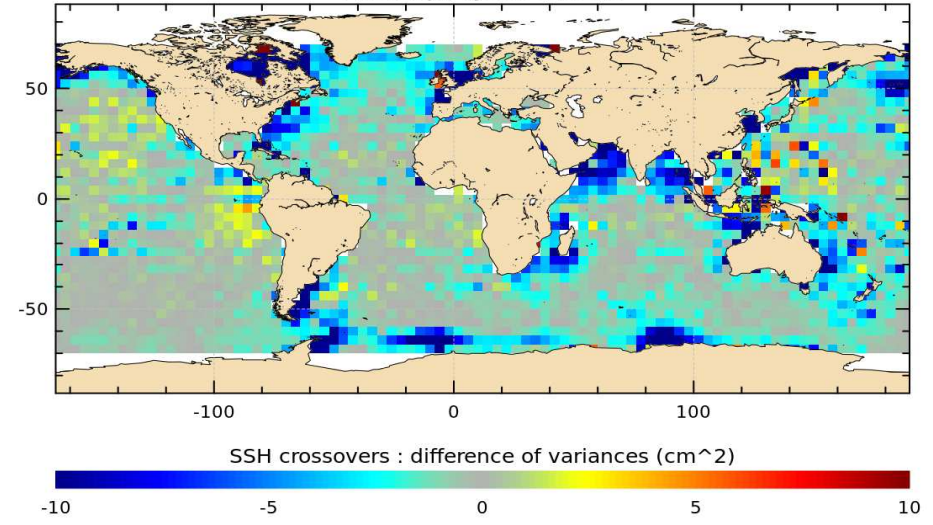
Mission en, cycles 9 to 93



Nbr :	2719	Std Dev :	109.28763	Min :	-2841.1732
Mean :	-8.5587485	Median :	-0.85062402	Max :	1546.0324

VAR(SSH with FES2014NEWComple) - VAR(SSH with FES2012)

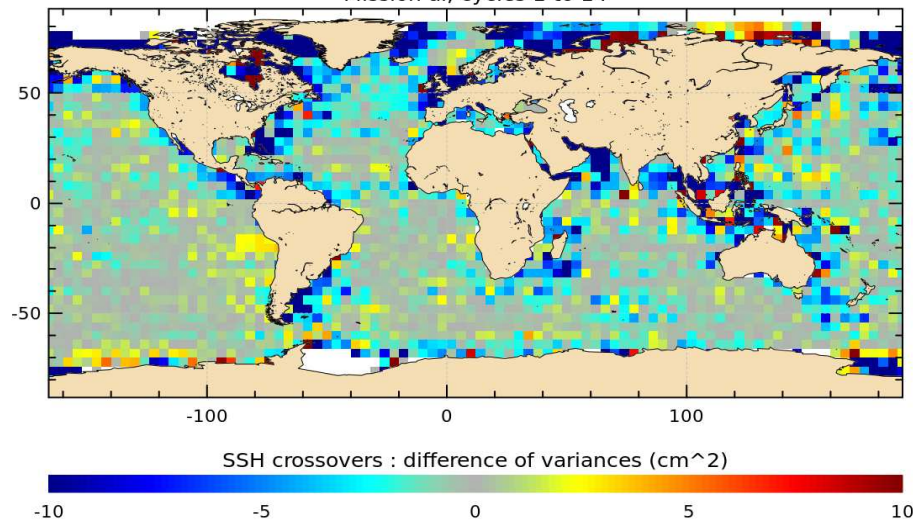
Mission j1, cycles 1 to 248



Nbr :	2338	Std Dev :	84.37983	Min :	-3577.6267
Mean :	-4.8238739	Median :	-0.79503504	Max :	876.9946

VAR(SSH with FES2014NEWComple) - VAR(SSH with FES2012)

Mission al, cycles 1 to 14

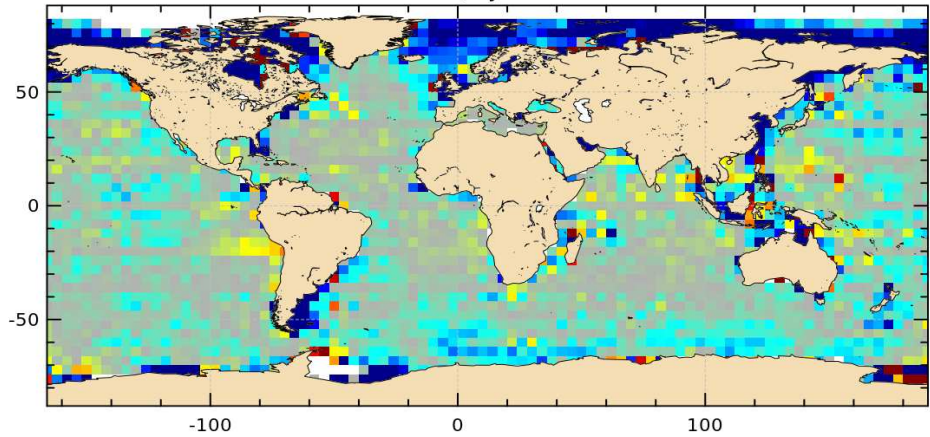


Nbr :	2676	Std Dev :	120.79461	Min :	-3764.5232
Mean :	-9.0575494	Median :	-0.51436726	Max :	852.35299

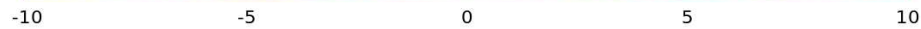
Variance of SSH crossover differences FES2014 vs FES2012

VAR(SSH with FES2014) - VAR(SSH with GOT4V10c)

Mission en, cycles 9 to 93

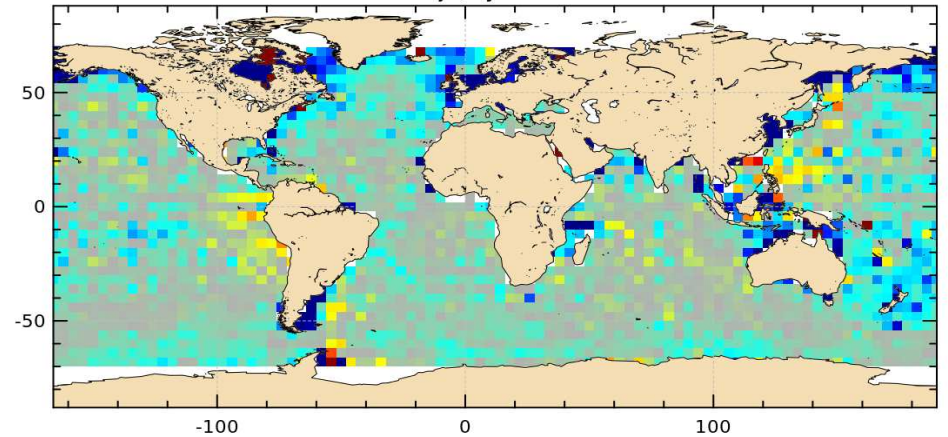


SSH crossovers : difference of variances (cm²)



VAR(SSH with FES2014) - VAR(SSH with GOT4V10c)

Mission j1, cycles 1 to 248



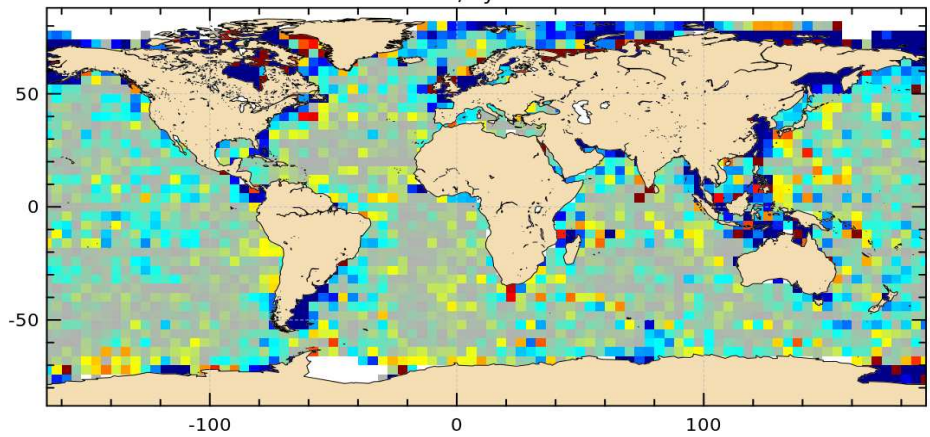
SSH crossovers : difference of variances (cm²)



FES2014 vs GOT4v10c Variance of SSH crossover differences

VAR(SSH with FES2014NEWComple) - VAR(SSH with GOT4V10c)

Mission al, cycles 1 to 12

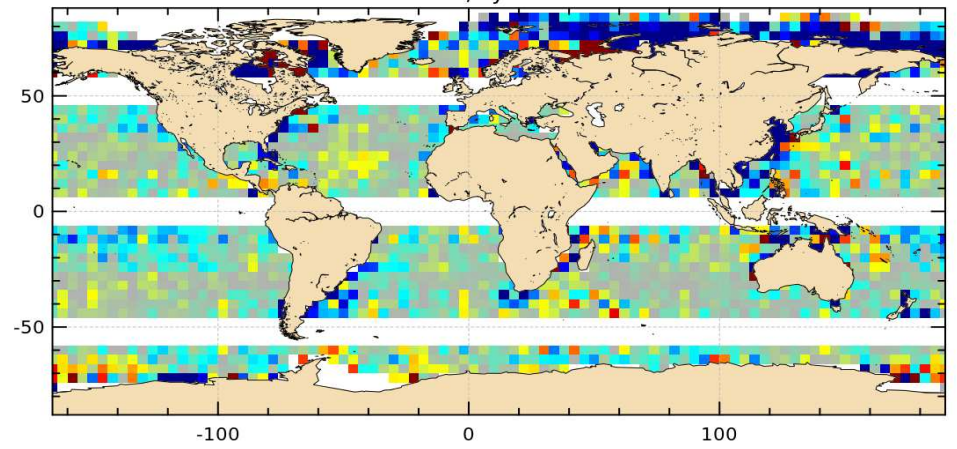


SSH crossovers : difference of variances (cm²)



VAR(SSH with FES2014) - VAR(SSH with GOT4V10c)

Mission c2, cycles 14 to 64

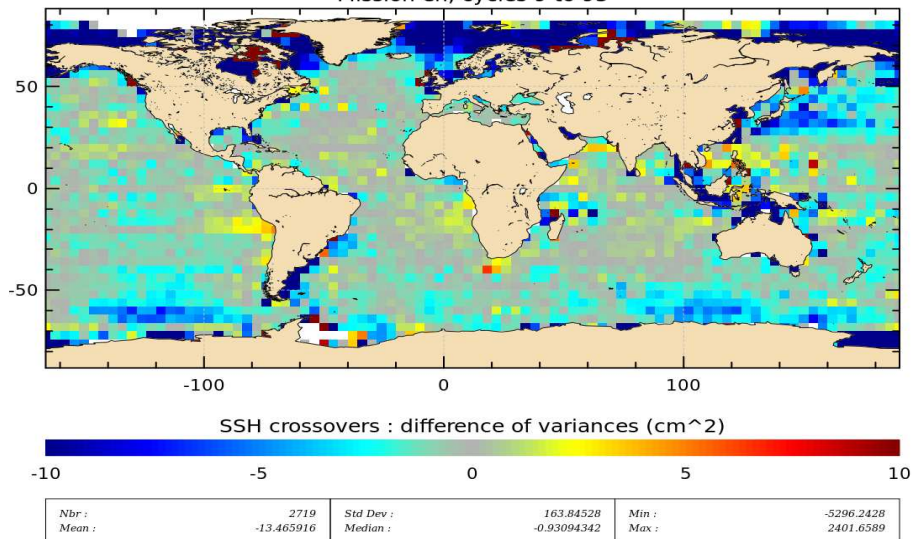


SSH crossovers : difference of variances (cm²)



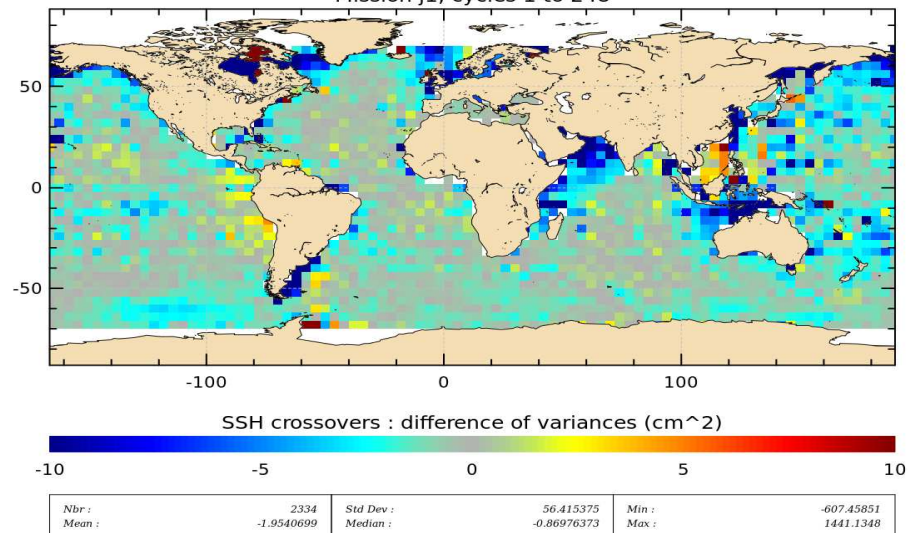
VAR(SSh with FES2014) - VAR(SSh with TPXO)

Mission en, cycles 9 to 93



VAR(SSh with FES2014) - VAR(SSh with TPXO)

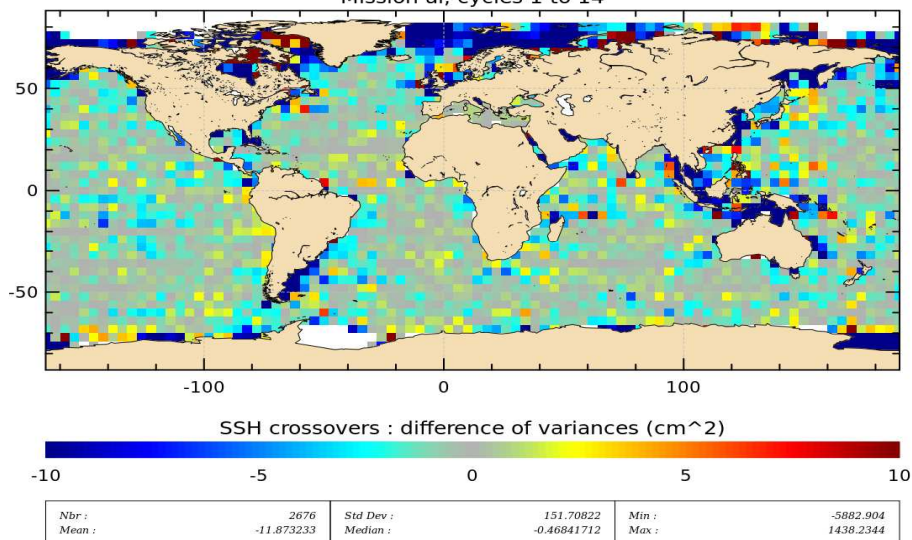
Mission j1, cycles 1 to 248



FES2014 vs TPXO8 Variance of SSH crossover differences

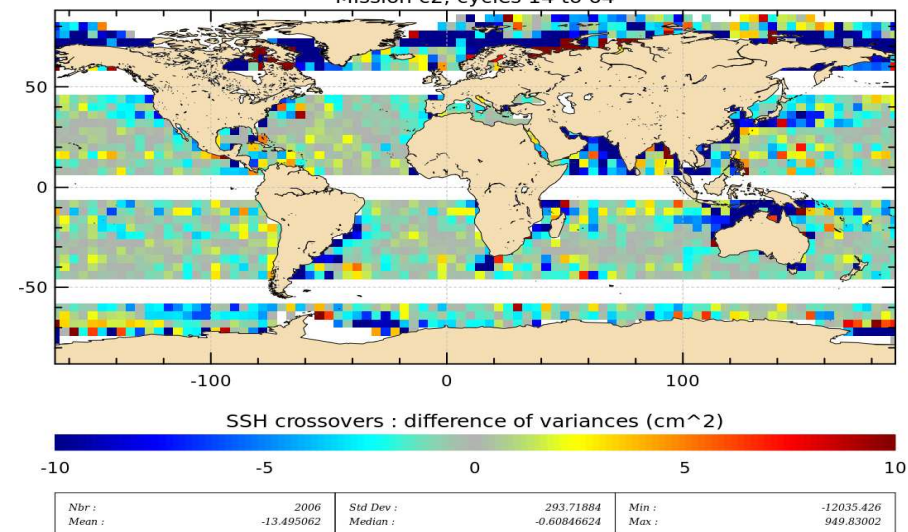
VAR(SSh with FES2014) - VAR(SSh with TPXO)

Mission a1, cycles 1 to 14



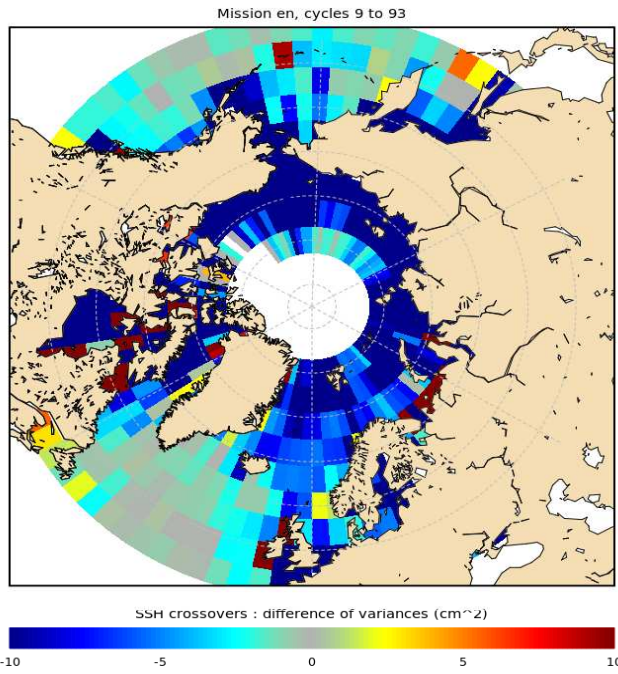
VAR(SSh with FES2014) - VAR(SSh with TPXO)

Mission c2, cycles 14 to 64

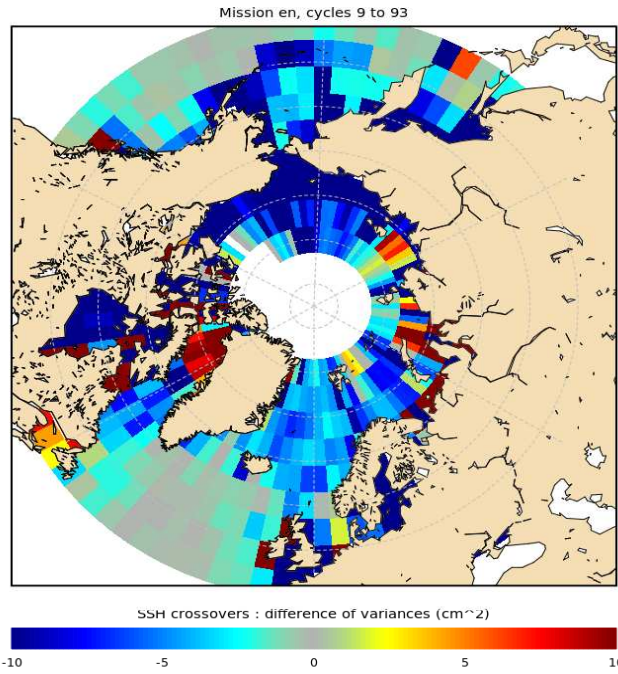


Arctic

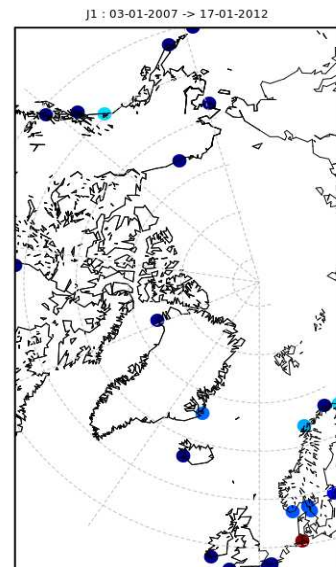
VAR(SSH with FES2014NEWComple) - VAR(SSH with GOT4V10)



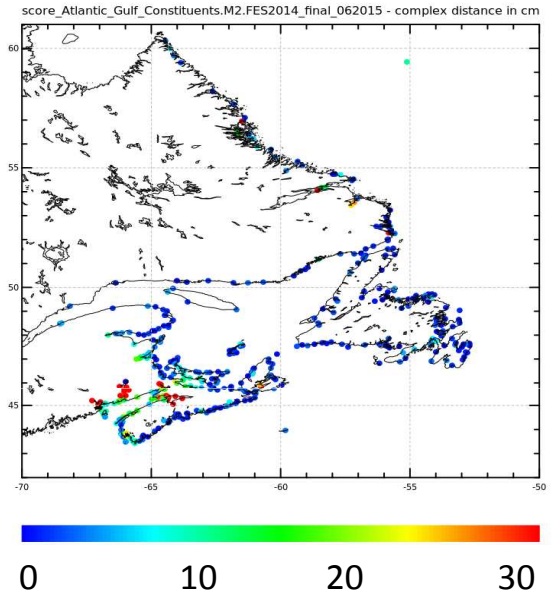
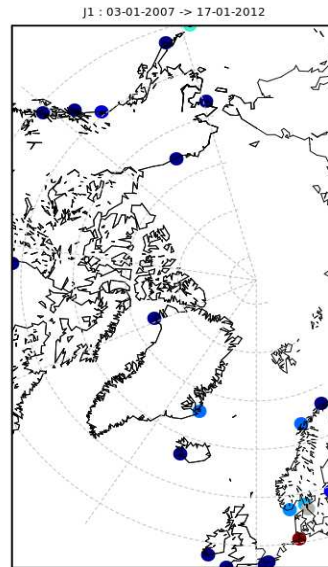
VAR(SSH with FES2014NEWComple) - VAR(SSH with DTU10)



AR(TG_MAR_FES2014) - VAR(TG_MAR_GOT4V10)



VAR(TG_MAR_FES2014) - VAR(TG_MAR_DTU10)



	M2	K1	N2
FES2014	11.9	1.9	8
DTU10	16.4	2.6	8.6
GOT4v8	14.6	3.3	8.3

Conclusions

- FES2014 atlas shows a strong improvement compared to previous version FES2012
- FES2014 has better/~ performances than other models for all main waves
- Global temporal validation vs FES2012, DTU10, GOT4.8, TPXO8
 - => Improvement in coastal/shelf regions, in deep ocean areas and at high latitudes + Arctic

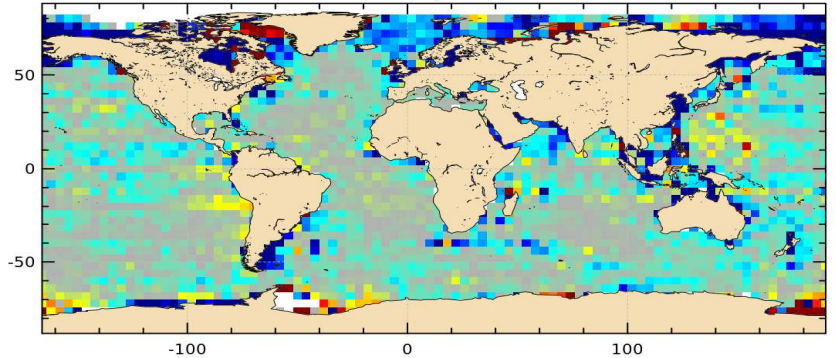
- Some more validation diagnostics are still being computed by independent teams also
- A specific task has been devoted to the analysis of the 58.77 days MSL signals:
 - => Cf. next presentation from **Zawadzki et al.**

- **Tidal currents are being computed and will be available at the same resolution of 1/16°**
- **Specific validation of the tidal currents is planned in 2016 around Australia**
- **Specific FES2014 loading tide will be computed within next monthes**
- **Scientific paper on FES2014 atlas should be submitted within next monthes**

- More slides ...

VAR(SSH with FES2014NEWComple) - VAR(SSH with DTU10)

Mission en, cycles 9 to 93



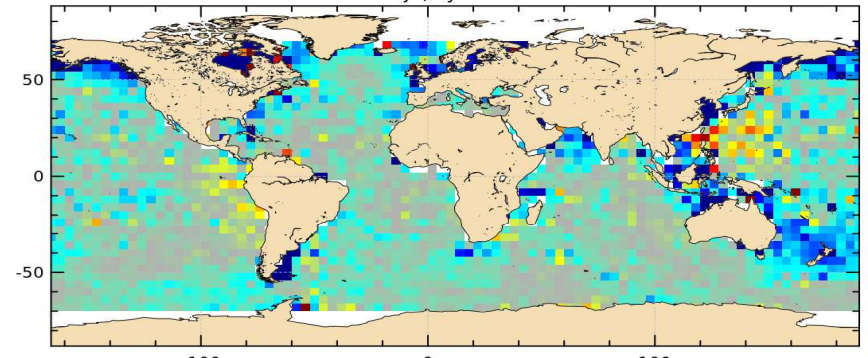
SSH crossovers : difference of variances (cm²)



Nbr :	2719	Std Dev :	129.87961	Min :	-4662.7791
Mean :	-8.2783945	Median :	-0.82604334	Max :	2490.4665

VAR(SSH with FES2014NEWComple) - VAR(SSH with DTU10)

Mission j1, cycles 1 to 248



SSH crossovers : difference of variances (cm²)

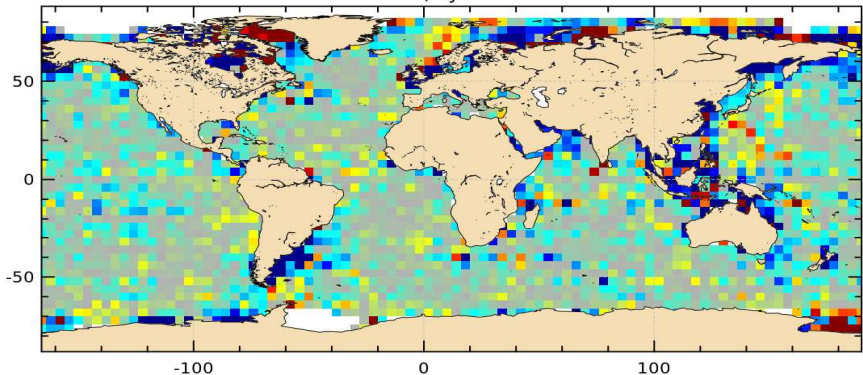


Nbr :	2338	Std Dev :	149.96809	Min :	-6245.1517
Mean :	-8.1556934	Median :	-0.9345344	Max :	704.10748

FES2014 vs DTU10 SSH

VAR(SSH with FES2014NEWComple) - VAR(SSH with DTU10)

Mission a1, cycles 1 to 14



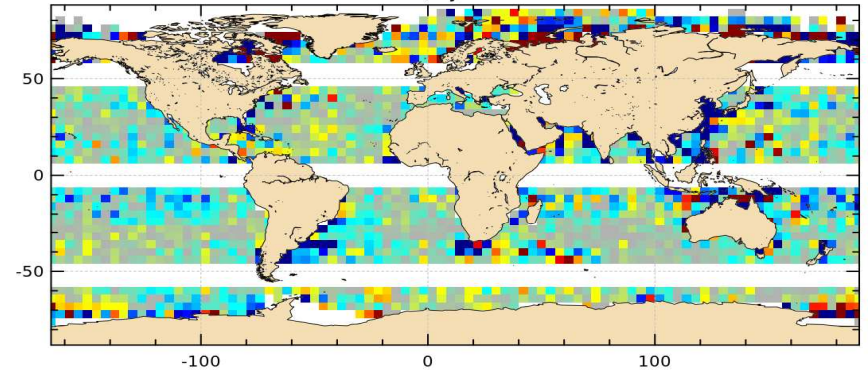
SSH crossovers : difference of variances (cm²)



Nbr :	2676	Std Dev :	131.24416	Min :	-5332.9878
Mean :	-7.6001235	Median :	-0.47983987	Max :	810.97932

VAR(SSH with FES2014) - VAR(SSH with DTU10)

Mission c2, cycles 14 to 64



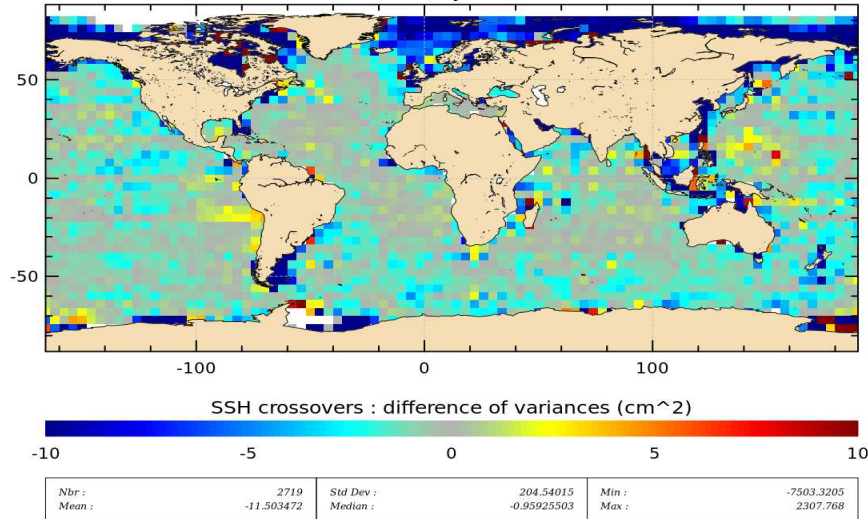
SSH crossovers : difference of variances (cm²)



Nbr :	1984	Std Dev :	111.76091	Min :	-3580.4914
Mean :	-3.0710089	Median :	-0.45930251	Max :	2984.8771

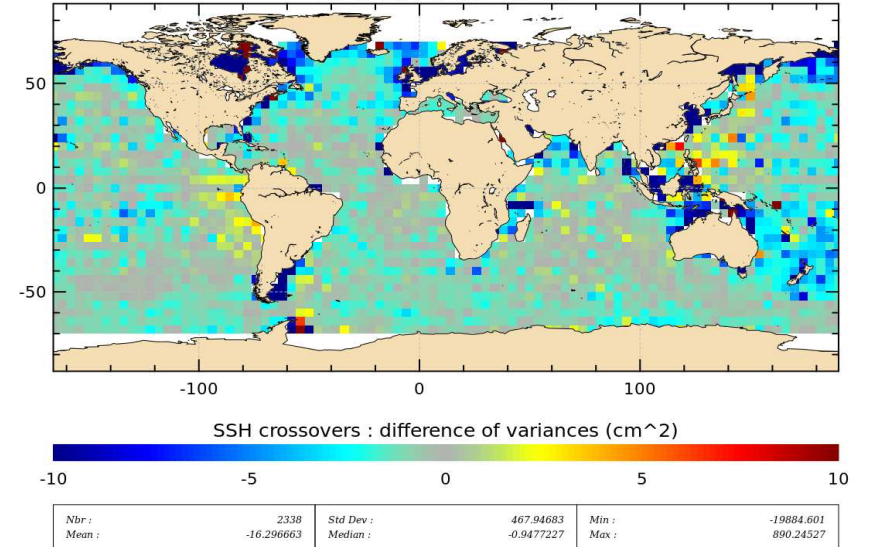
VAR(SSH with FES2014NEWComple) - VAR(SSH with GOT4V10)

Mission en, cycles 9 to 93



VAR(SSH with FES2014NEWComple) - VAR(SSH with GOT4V10)

Mission j1, cycles 1 to 248

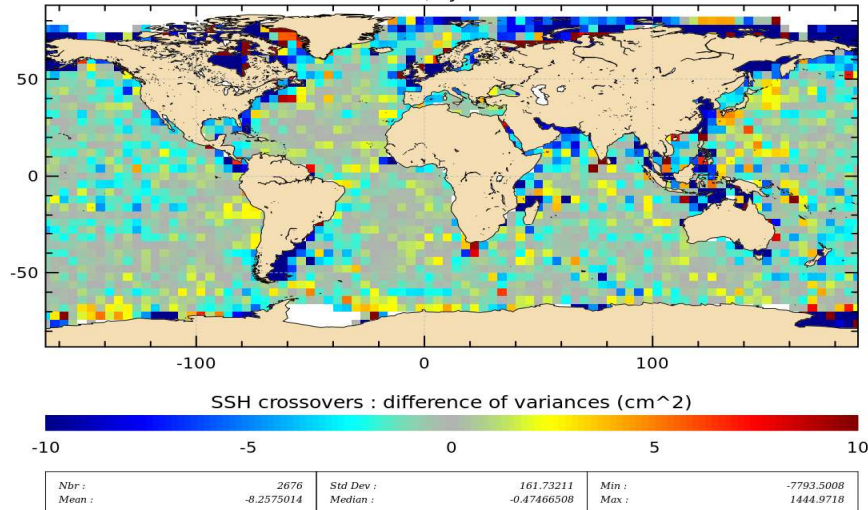


FES2014 vs GOT4V8-10

SSH

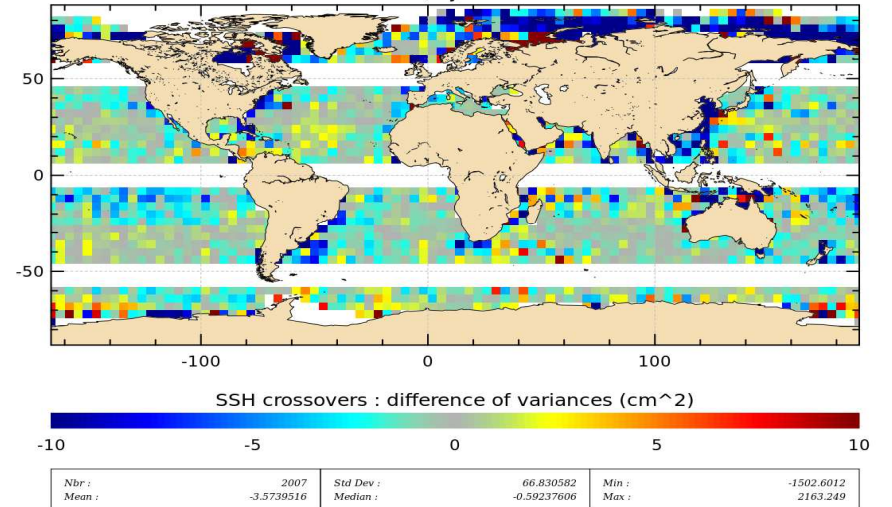
VAR(SSH with FES2014NEWComple) - VAR(SSH with GOT4V10)

Mission al, cycles 1 to 14

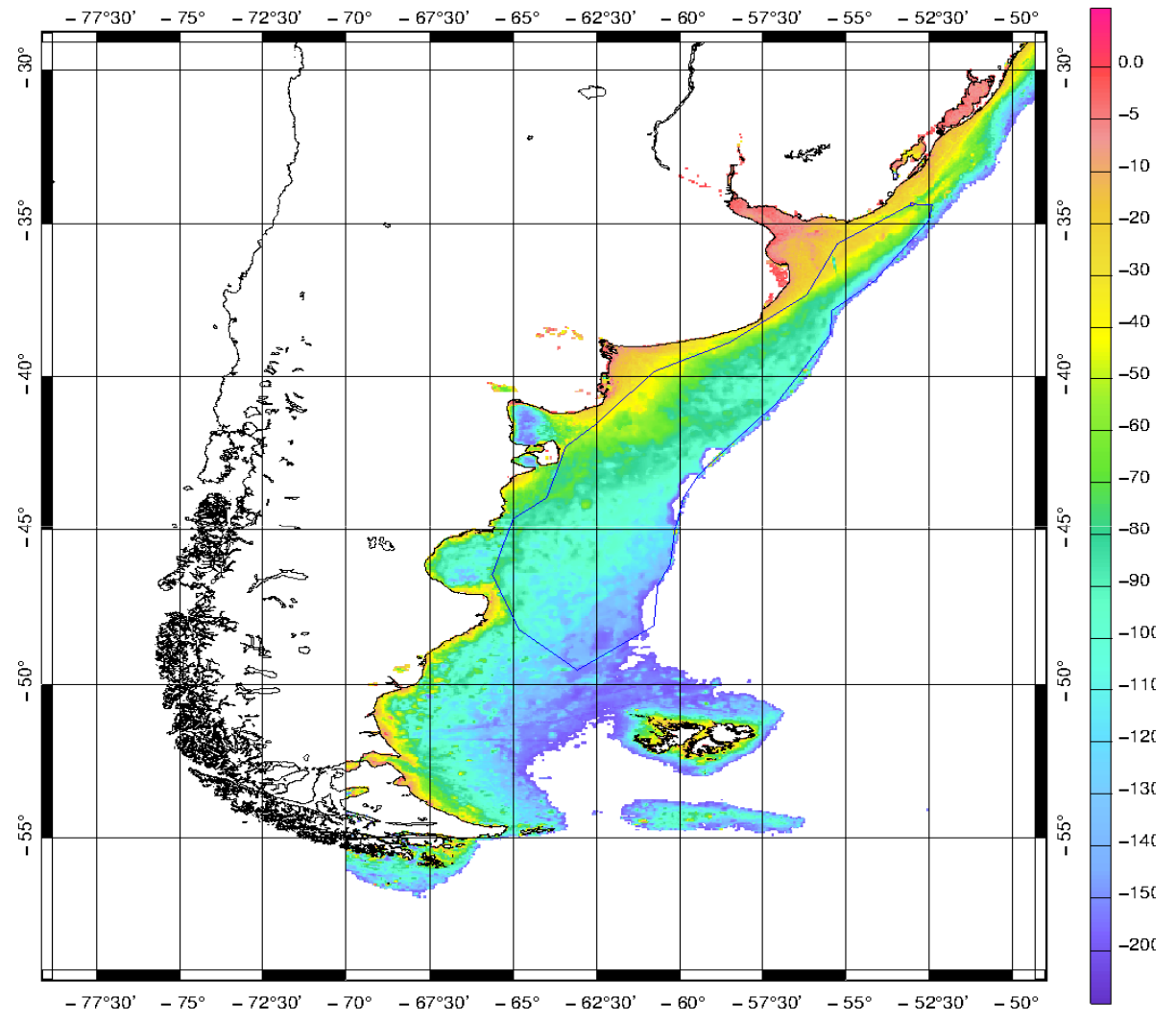
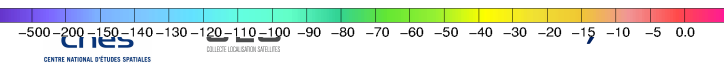
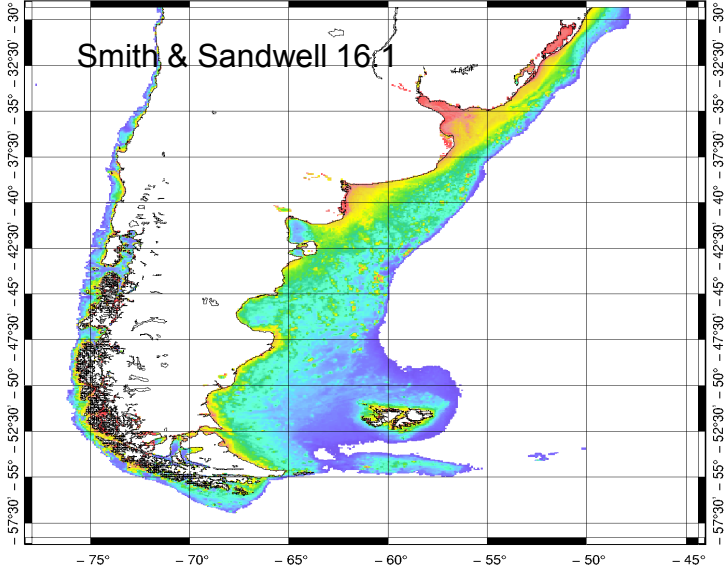
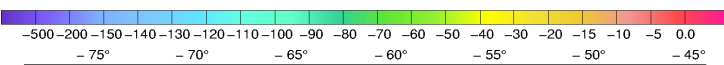
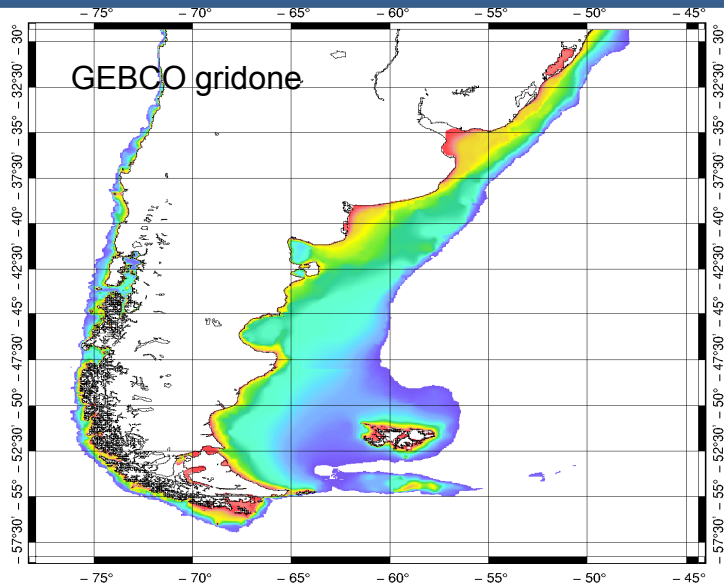


VAR(SSH with FES2014) - VAR(SSH with GOT4V10)

Mission c2, cycles 14 to 64



Zoom on Patagonian shelf



Smith & Sandwell 16.1, median filter applied