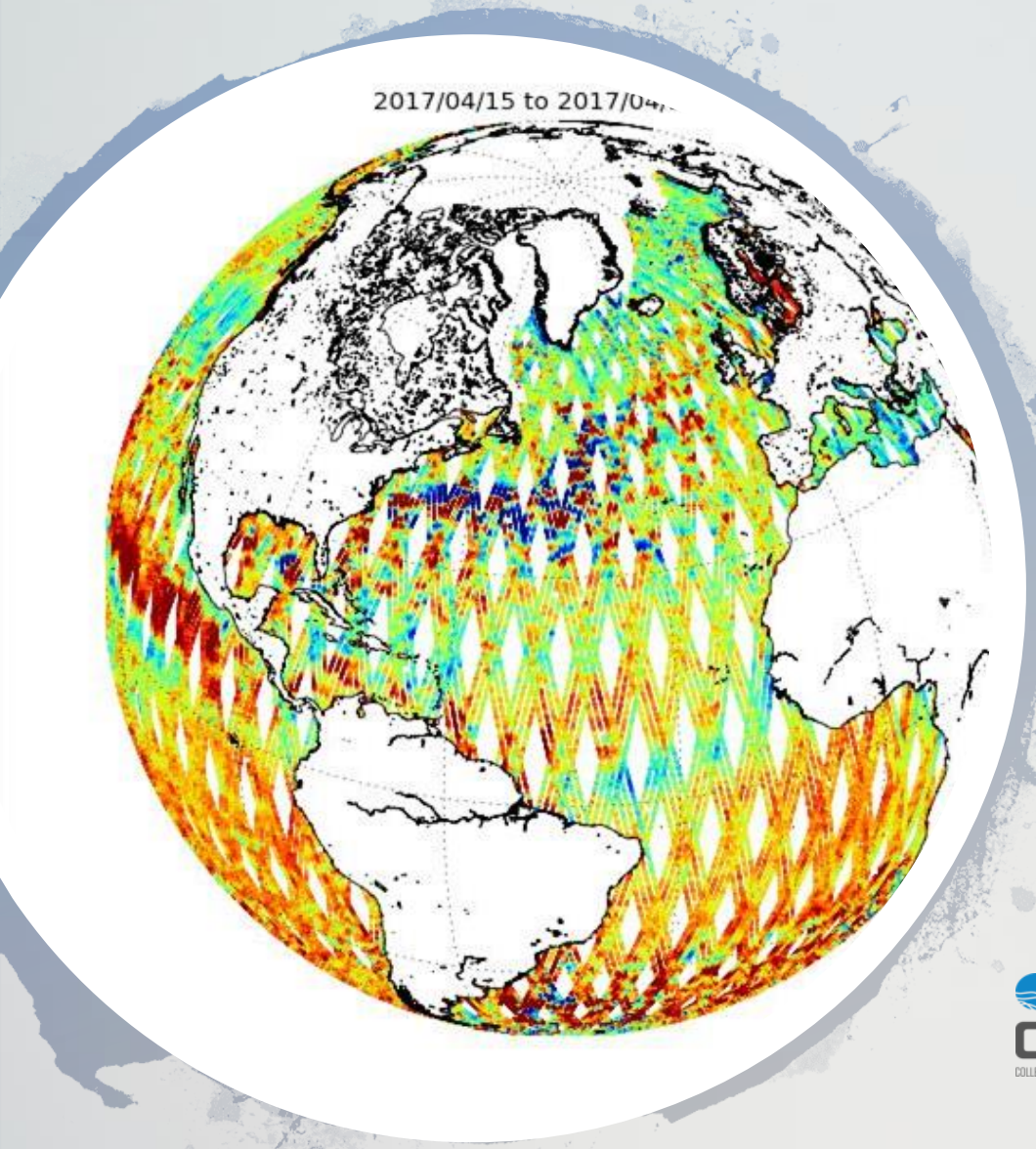

REPROCESSING of SEA LEVEL L2P products for 28 years of altimetry missions

OSTST 2020

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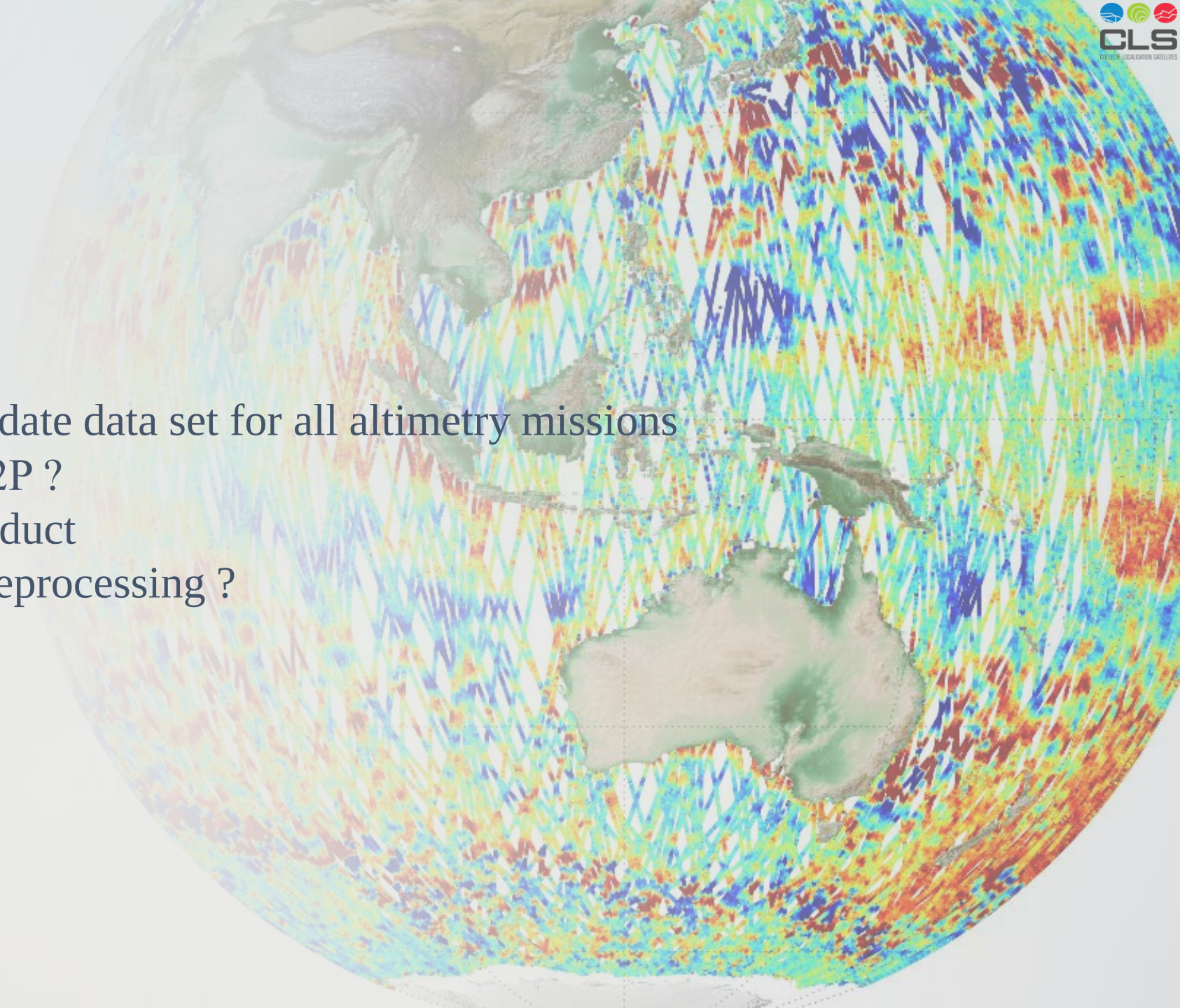
L2P REPROCESSING

- Context : unified and up to date data set for all altimetry missions
- Product content : what’s L2P ?
- Added value versus L2 product
- What is new for the 2020 reprocessing ?
- Standard evolutions
- Overall improvements
- Global mean sea level
- Data availability



CONTEXT : unified and up to date data set for all altimetry missions

Since the launch of TOPEX/Poseidon and ERS-1 in the early 90's more than 10 other Altimetry missions were launched and operated by different agencies. The level 2 data (destinated to expert users) are distributed using different file formats (binary, netcdf) and contain different geophysical standards used to compute the sea level anomaly.

Some dataset evolve rapidly and are regularly reprocessed, whereas other datasets, especially from finished missions are seldom reprocessed or not at all (and therefore do not profit from new standards).

In the frame of the SALP (Service d'Altimétrie et de Localisation Précise) project supported by CNES (Centre National d'Etudes Spatiales) and of the Sentinel-3 Marine Altimetry L2P-L3 Service (operated under an EUMETSAT contract in the frame of the Copernicus Programme funded by the European Union), L2P data are available to users for all the altimeter missions.

Last L2P 2018 reprocessing also benefited from ESA Sea Level CCI project :
Download data and handbook on the AVISO+ website https://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products/global/along-track-sea-level-anomalies-l2p.html

sea level cci

cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

SALP Service Altimetrie & Localisation Precise

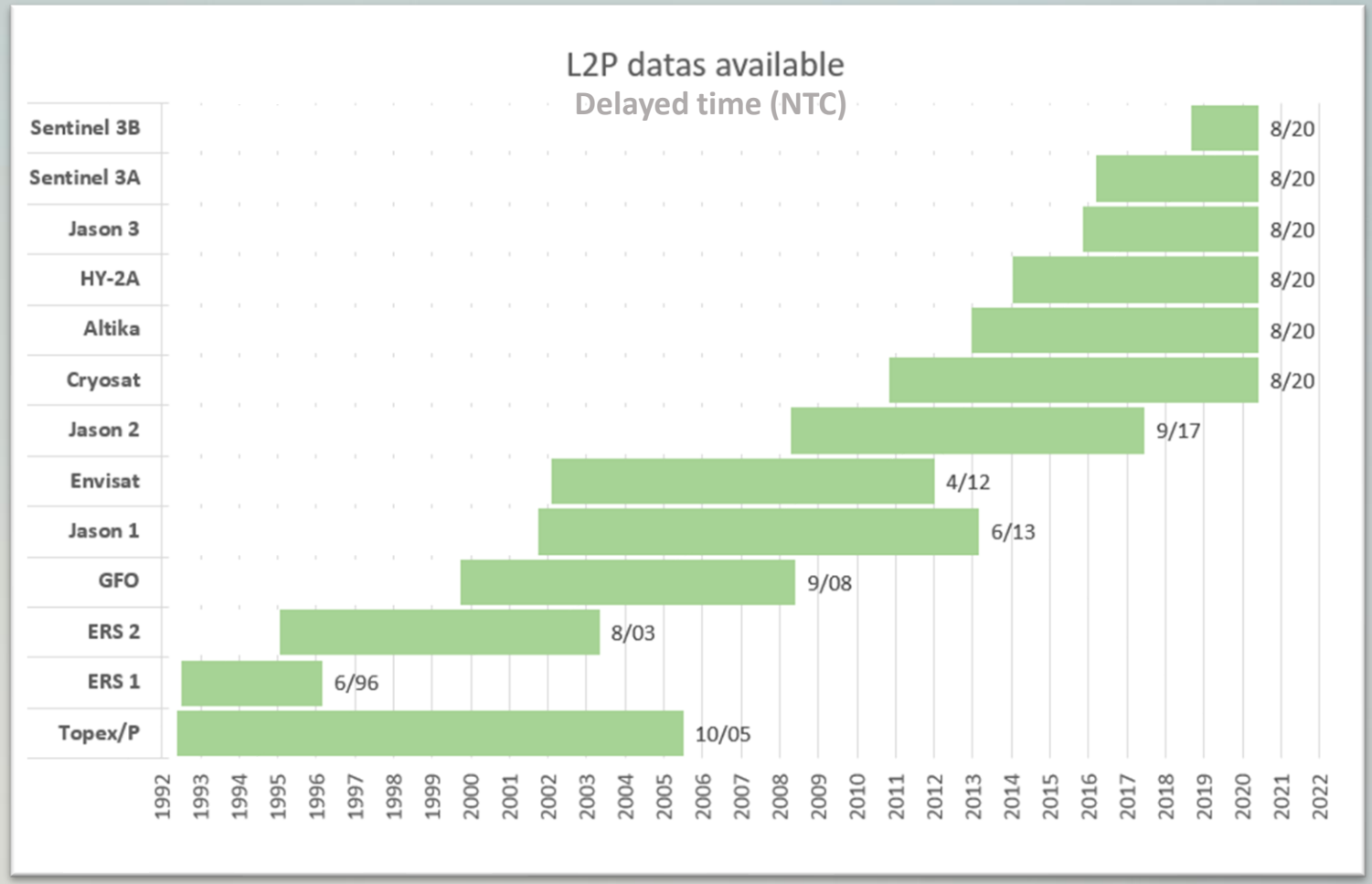
Copernicus Europe's eyes on Earth

EUMETSAT

PRODUCT CONTENT : what's L2P ?

The homogeneous along-track products Level 2 Plus contain for each mission (only on marine surface) :

- the sea level anomaly (SLA)
- the corrections used to compute the SLA (range, orbital altitude, environmental and geophysical corrections)
- a validity flag, enabling users to discard data with spurious measurements
- Furthermore, an inter-mission bias is applied in order to have consistent time series since TOPEX/Poseidon.



ADDED VALUE VERSUS L2 PRODUCT :

L2P products are easy to use (netcdf format) homogenous along-track mono-mission products, providing as much as possible the same updated corrections and models for the altimeter missions, in order to facilitate inter-mission comparisons.

Global and regional sea-level biases are corrected versus a reference mission

Selection of valid measurements to calculate sea-level anomaly

Empirical correction to remove errors in L2 products (e.g. time tag bias)

Regularly updated to use last L2 reprocessing and last recommended corrections (geophysical and instrumental)

Reprocessed L2P products are the inputs for 2 Copernicus Services (CMEMS and C3S), for their own reprocessing (L3 and L4 products) for assimilation experiments and climate monitoring

Taburet et al. 2019, DUACS DT-2018: 25 years of reprocessed sea level altimeter products

WHAT IS NEW FOR THE 2020 REPROCESSING ?

The whole altimetry L2P time-series was reprocessed during 2020

Available in netcdf 4 format

The reprocessed L2P products were based on recently reprocessed L2 data for several missions:

- ENVISAT V3.0
- Sentinel-3 A & Sentinel-3 B Baseline Collection 004
- SARAL GdrF
- Cryosat Ocean Baseline C
- Jason-3 GDR-F was not available for the L2P reprocessing. For more information on the coming Jason-3 GDR-F data see *F.Bignalet-Cazalet et al., splinter session "Cal/Val for CDR".*

Use of WGS84 Reference instead of Topex Ellipsoid

For each mission, the retracking parameters from L2 products (e.g. range) are kept, but each (geophysical and environmental) correction from L2 used for sea level anomaly computation was evaluated and compared to other versions of the correction. Based on OSTST's recommendations for new standards and the thorough evaluation of all corrections, the best standards were selected to ensure the quality and consistency of the next version of L2P.

-> The reprocessed L2P data set are presented with highlights on some of the improvements.

STANDARDS EVOLUTIONS :

Reprocessing L2 | no update = 2018 | New for 2020

Update	Poseidon	Topex	Jason 1	Jason 2	Jason 3	ERS-1	ERS-2	ENVISAT	SARAL	Sentinel 3A	Sentinel 3B	Geosat FO	Cryosat 2	HY 2A
ORBIT	GSFC STD18		POE-E	POE-F		Reaper		POE-E	POE-F	POE-F		GSFC	POE-F	POE-D
IONOSPHERIC	DORIS	SLOOP		SLOOP (SSB C)	SLOOP	NIC09	GIM	Filtre L2 / GIM	GIM	Filtre L2		GIM		
SEA STATE BIAS	BM4	Non parametric [N. Tran 2010]	2D [N. Tran 2015]	2D J2 [N. Tran 2012]		BM3 [Gaspar Ogor 1994]	Non parametric [Mert 2005]	2D [N. Tran 2017]	2D [N. Tran 2018]	2D J2 [N. Tran 2012]		Non parametric [N. Tran & S. Labroue 2010]	2D [N. Tran 2018] Baseline C	Non Parametric [N. Tran 2012 Vent S. Labroue]
WET TROPOSPHERE	GPD+ [Fernandes et al. 2015]		JMR (GDRE) radiometer	AMR radiometer		GPD+ [Fernandes et al. 2015]		MWR radiometer reprocessed	Neuronal Network (5 entries) V4	MWR 3 radiometer		Radiometer and ECMWF	GPD+	ECMWF
DRY TROPOSPHERE	ERA5 (1-hour) model based													
DYNAMICAL ATMOSPHERIC CORRECTION	TUGO model forced with ERA 5 model				MOG2D HR forced with ECMWF	TUGO model forced with ERA 5 model			TUGO ERA 5 + MOG2D HR	MOG2D HR forced with ECMWF		TUGO forced with ERA5	TUGO ERA 5 + MOG2D HR	
OCEAN TIDE	FES 2014 B													
INTERNAL TIDE	ZARON 2019 (HRETv8.1 tidal frequencies: M2, K1, S2, O1)													
POLE TIDE	DESAI et al.2015 ; Mean Pole Location 2017													
SOLID TIDE	Elastic response													
MEAN SEA SURFACE	Composite (SCRIPPS,CNES/CLS15,DTU15)													

STANDARDS EVOLUTIONS : DYNAMICAL ATMOSPHERIC CORRECTION

Computation of a new DAC-ERA5 field :

see Carrere et al. in Tides-HF session "Using ERA5 meteorological reanalysis to improve the Dynamic Atmospheric Correction for altimetry"

- **ERA5 input model :**

-> change in resolution (spatial resolution ~30km 137 levels 1h (from IFS 2016) + frequency filtering <6h keeping tidal peaks)

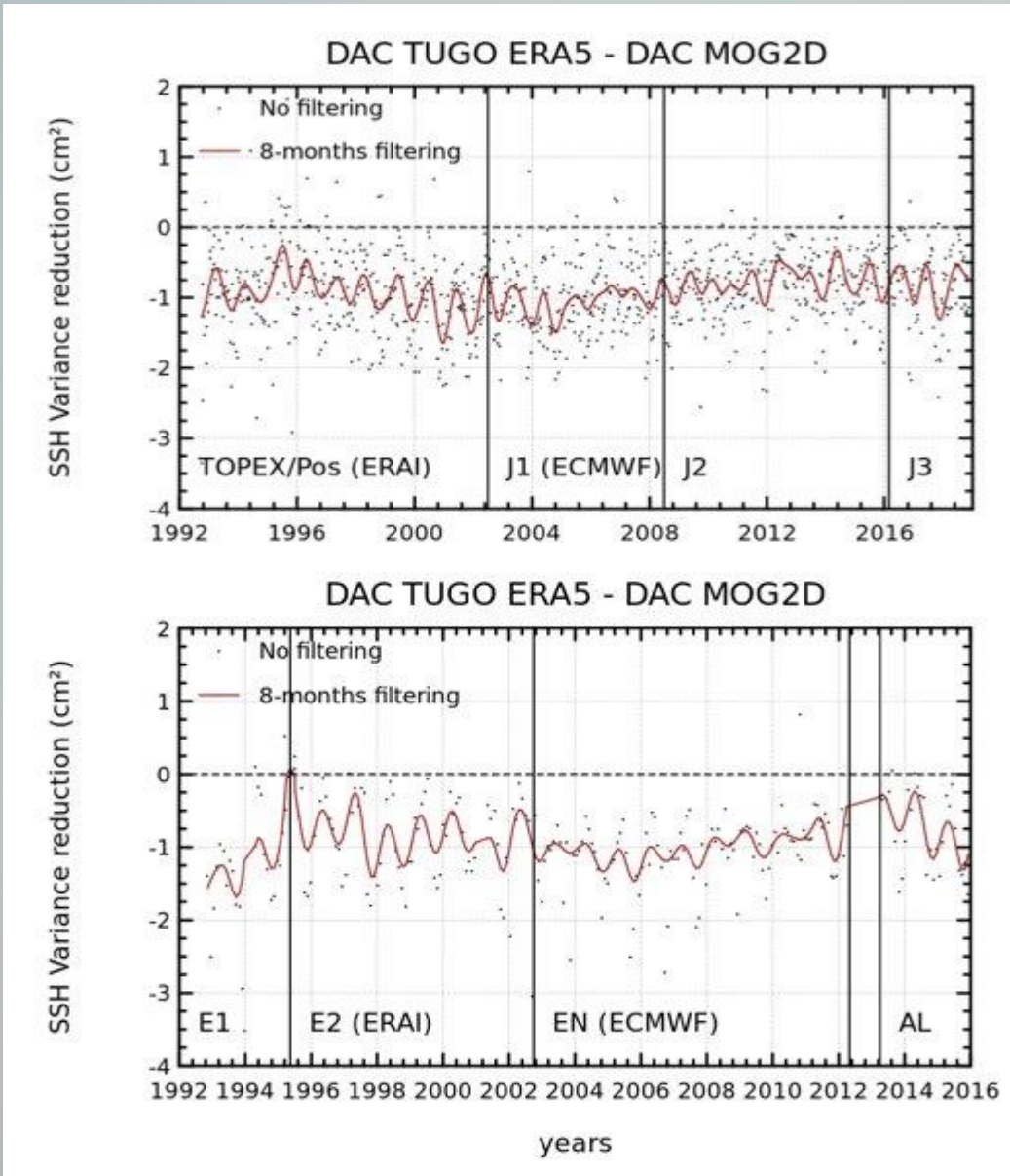
-> more observation assimilation

- **Better bathymetry :** FES2014 with better data on shelves in particular

- **TUGO Model**

- On the Caspian sea and hydrological surfaces : inverse barometer

STANDARDS EVOLUTIONS : DYNAMICAL ATMOSPHERIC CORRECTION



Temporal series of the mean variance reduction at crossovers on global ocean on the altimetric area

- 2 long-term altimeter series are considered
  - TP-J1-J2-J3
  - E1-E2-EN-AL
- Comparison with CCI product corrections DAC MOG2D shows a **mean variance reduction of ~1 cm², stable in time**
- Even on most recent period, the improvement remains visible showing **the interest of the better bathymetry and the higher frequency forcing** compared to operational

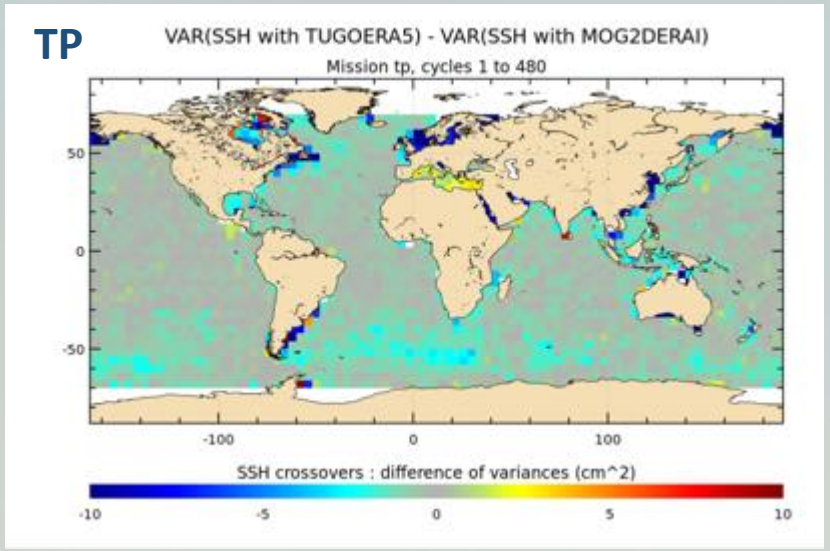
DAC TUGO ERA5 solution represents around 50% of total improvements on SSH variance reduction at crossovers in L2P 2021.

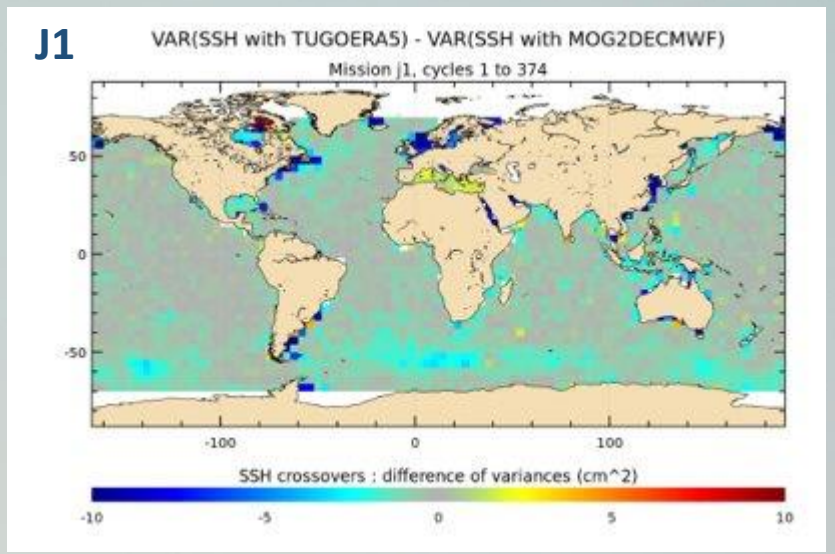
STANDARDS EVOLUTIONS : DYNAMICAL ATMOSPHERIC CORRECTION

mean sea surface height variance reduction at crossovers (10 days)

Strong variance reduction noted on continental shelves + in deep ocean at high latitudes
=> improvement of DAC-ERA5 due to better bathymetry and better forcing fields

Small variance raise noted in Mediterranean Sea => improvement of grid/bathymetry to come within FES2022 project

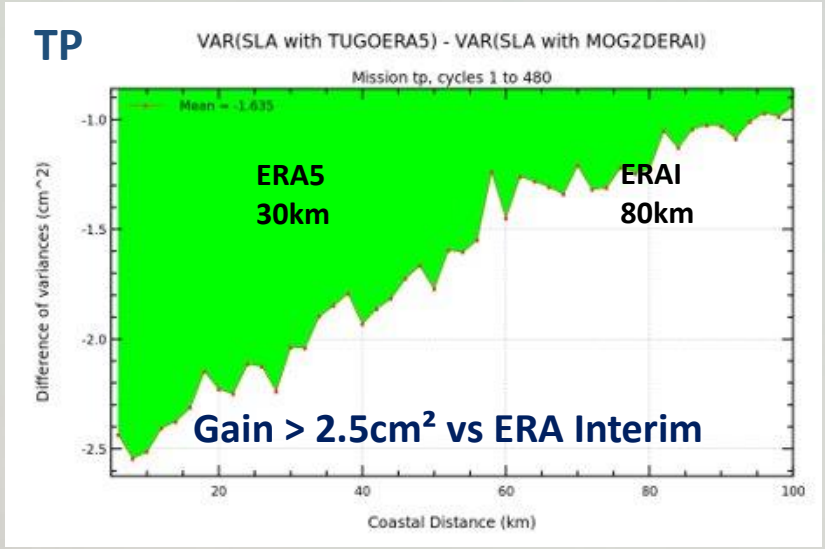


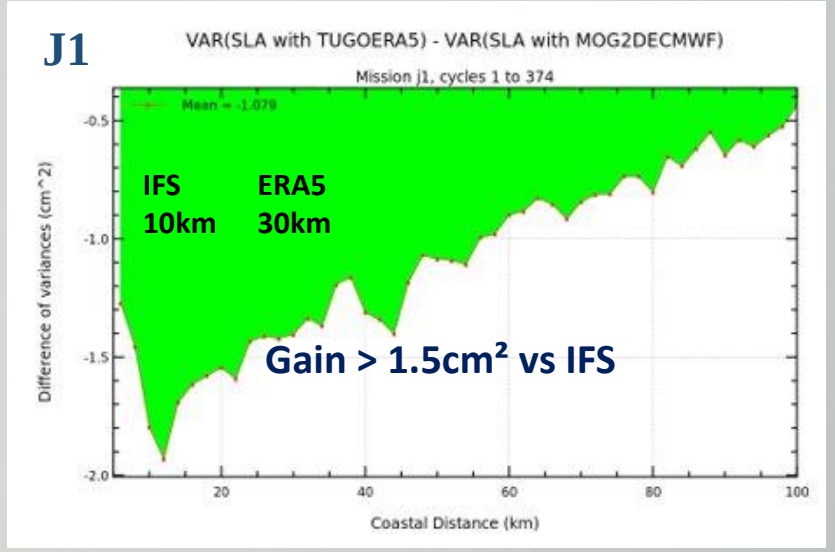


mean sea level anomaly variance reduction in function of coastal distance

Strong positive impact is noted, likely due to the better bathymetry and better spatial resolution of ERA5 compared to ERA Interim

Positive impact also noted vs operational DAC-ECMWF, likely explained by 1-hour temporal sampling of ERA5

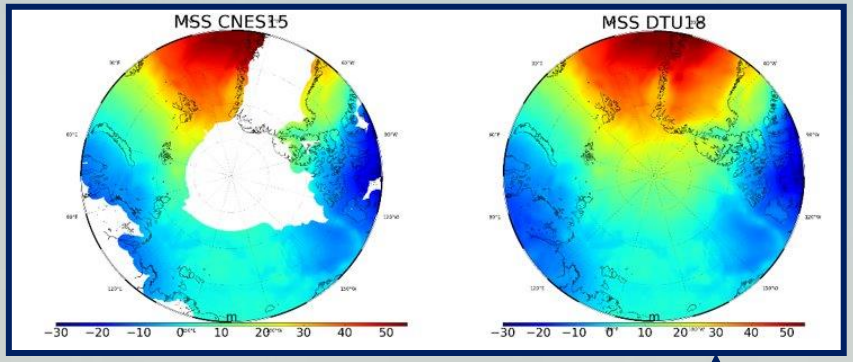


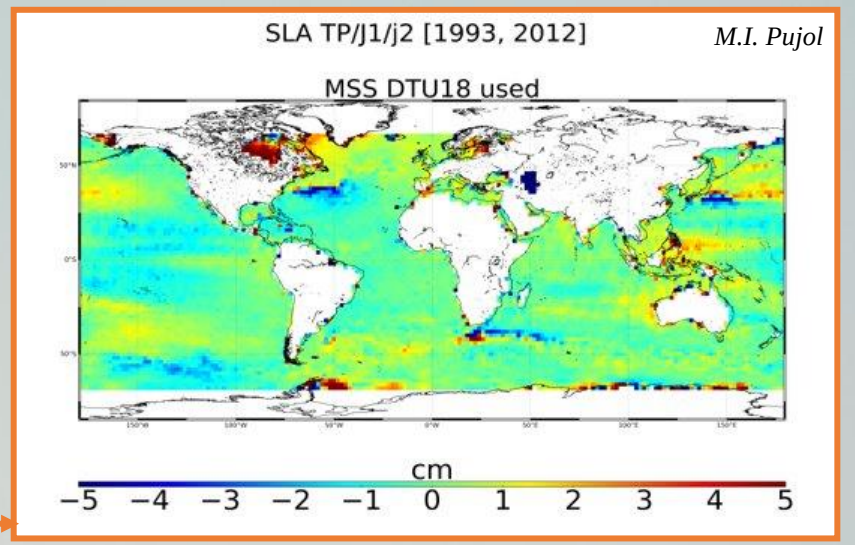


STANDARDS EVOLUTIONS : MEAN SEA SURFACE

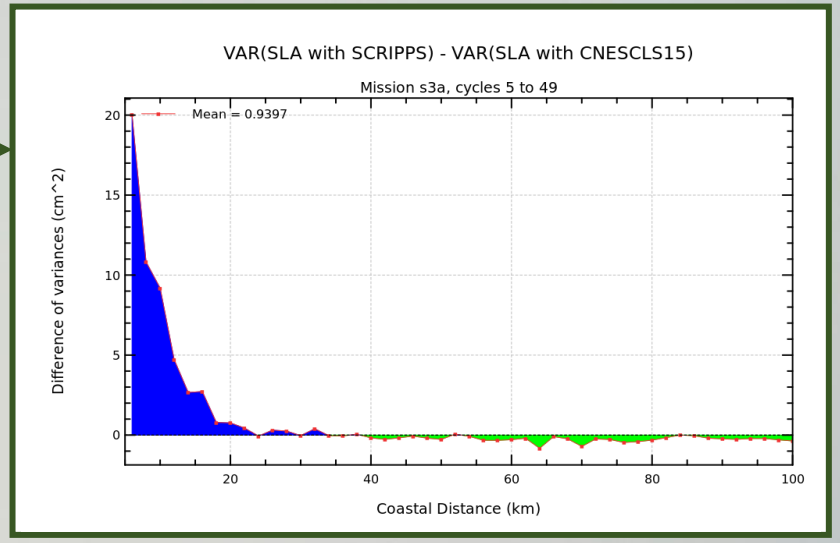
Mean sea surface solutions explored :

- CNES/CLS 15
- SCRIPPS
- DTU18
- DTU15





	CNES15	SCRIPPS	DTU18/DTU15
Spatial coverage	-	+	++
Reference period	++	++	--
Accuracy at short wavelengths	--	++	+
Accuracy at long wavelengths	+	+	+
Coastal areas	+	-	
Other issues		Regional striped signal	Possible discontinuity at specific latitudes



-> Each solution contains issues and improvements

STANDARDS EVOLUTIONS : MEAN SEA SURFACE

A combined solution is proposed :

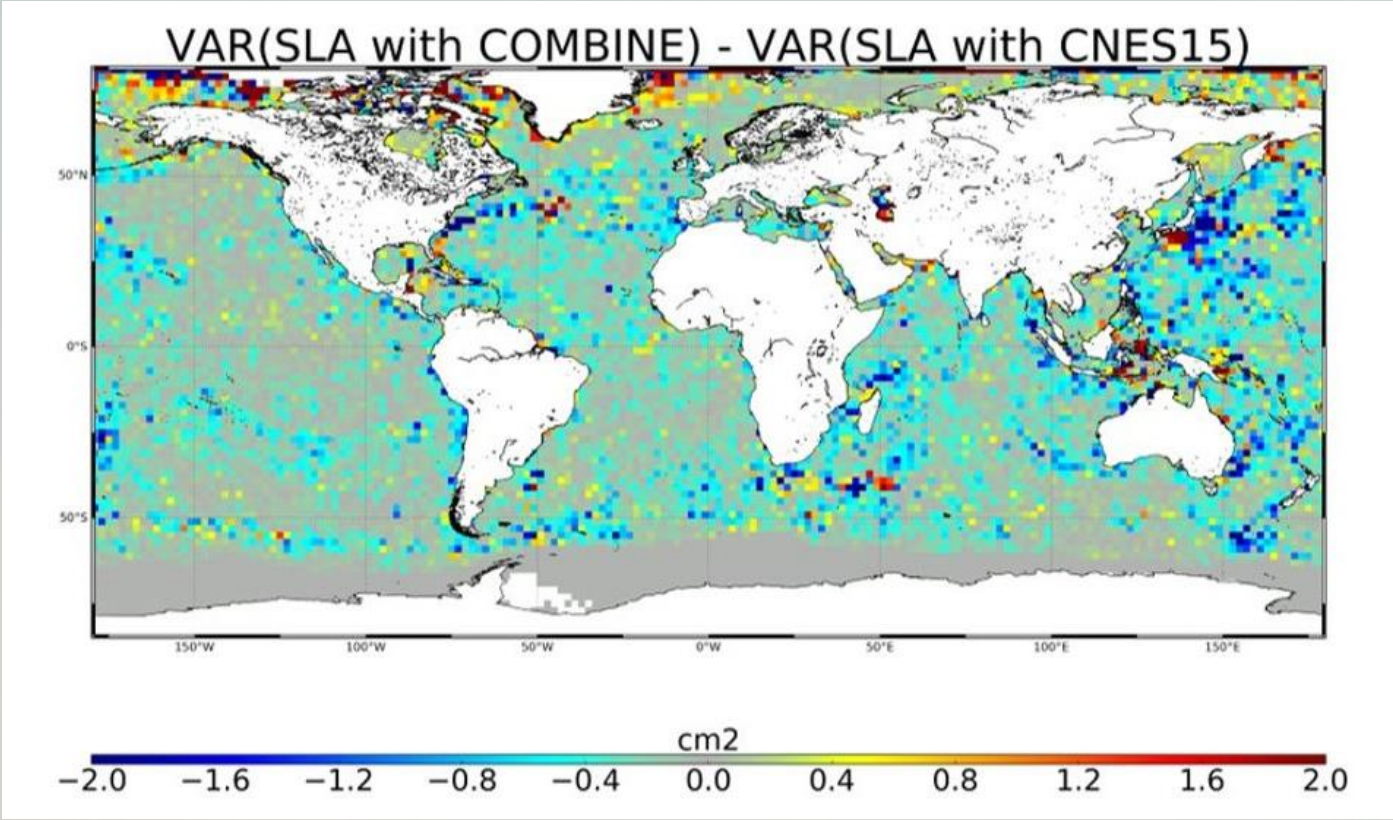
- **SCRIPPS** used in open ocean
- **CNES15** used in coastal and part of high latitudes areas
- **DTU15** used in Arctic region (latitudes > 81°N)

Improvements :

-> Accuracy at short wavelengths

-> Coastal areas

-> spatial coverage



SLA variance differences with MSS combined vs MSS CNES 15 for S3A

STANDARDS EVOLUTIONS : INTERNAL TIDE

Solution ZARON 2019 (HRET v8.1) : ***see "E. D. Zaron. Baroclinic tidal sea level from exact-repeat mission altimetry. Journal of Physical Oceanography, 49(1):193-210, 2019."***

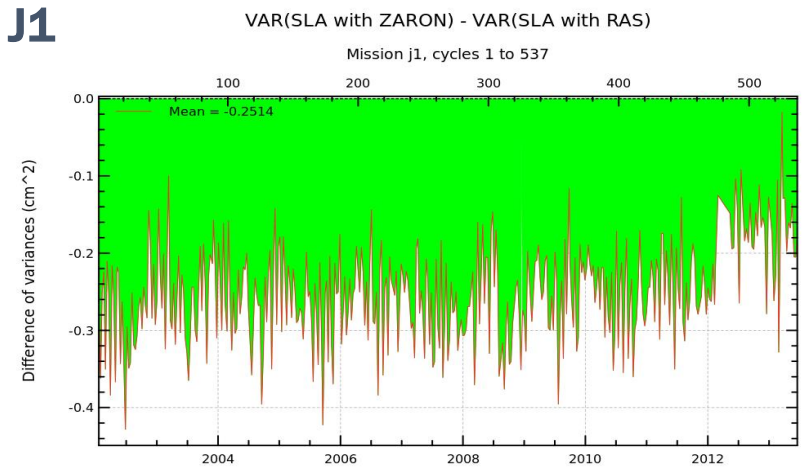
- **Included for the first time in L2P products**
- **Using M2, S2, K1, O1 waves computed by Zaron in 2019**

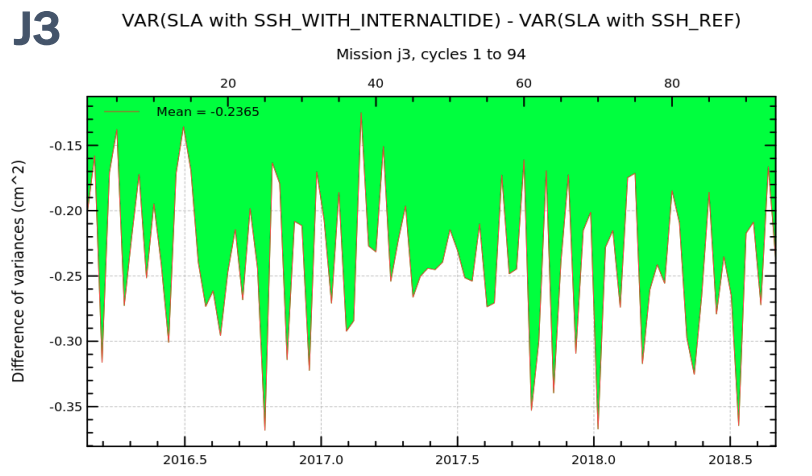
-> Significant impact at mesoscales

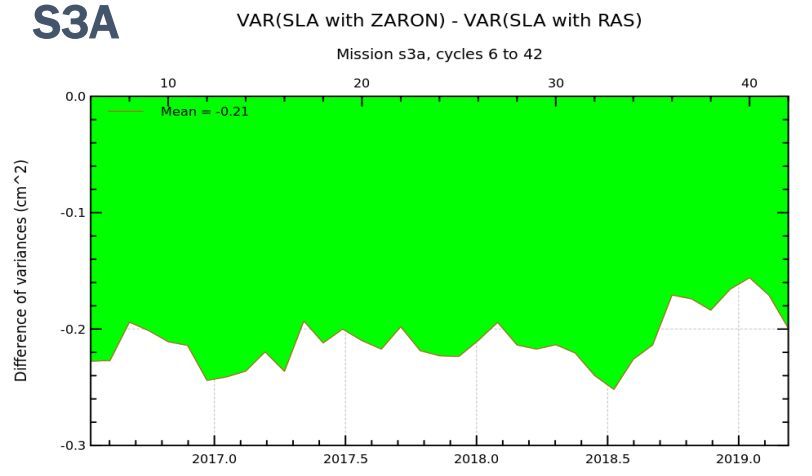
-> no impact on the global or regional Mean Sea Level

STANDARDS EVOLUTIONS : INTERNAL TIDE

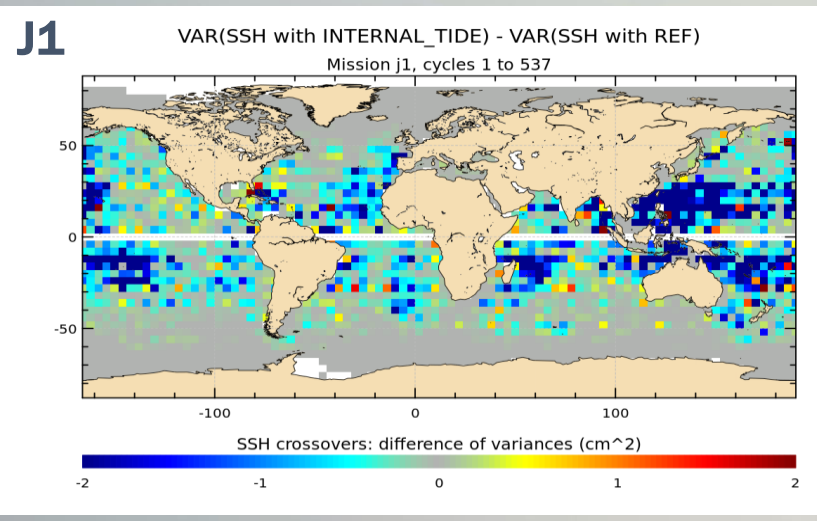
Reduction on the SLA's Variance

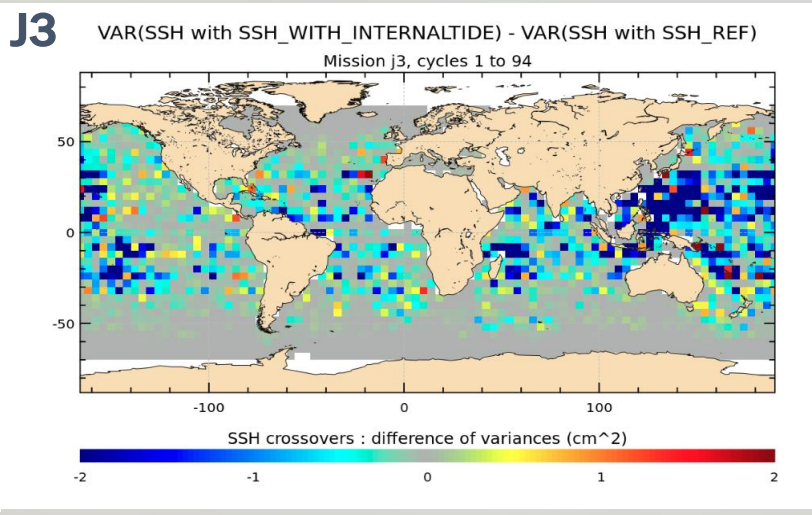


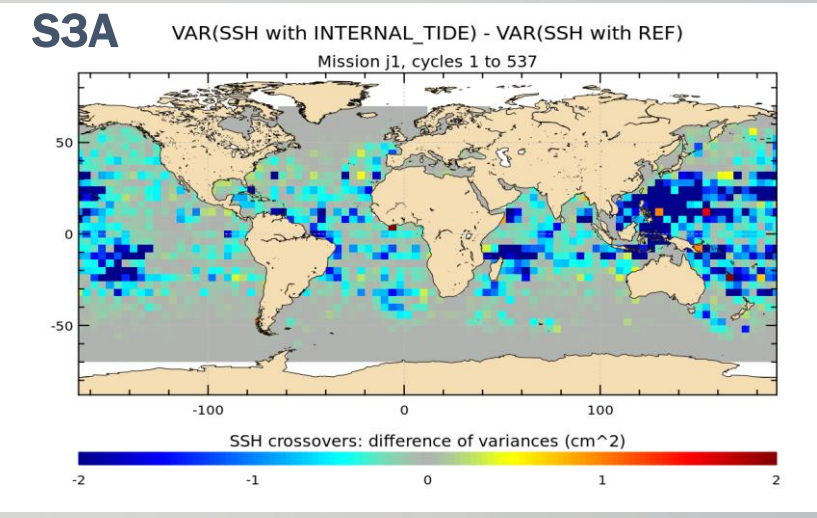




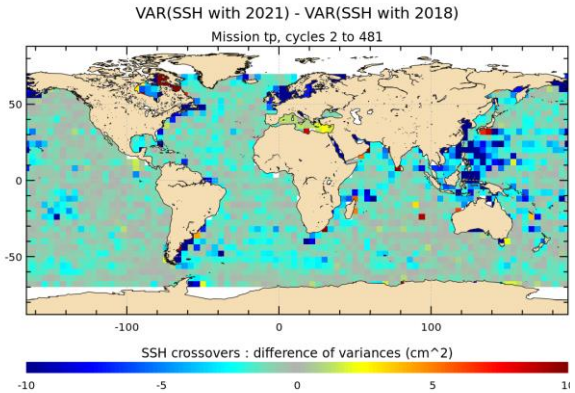
Reduction on sea surface height variance at crossovers (10days)

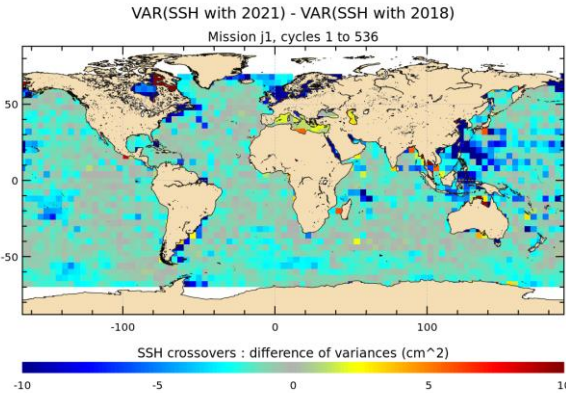


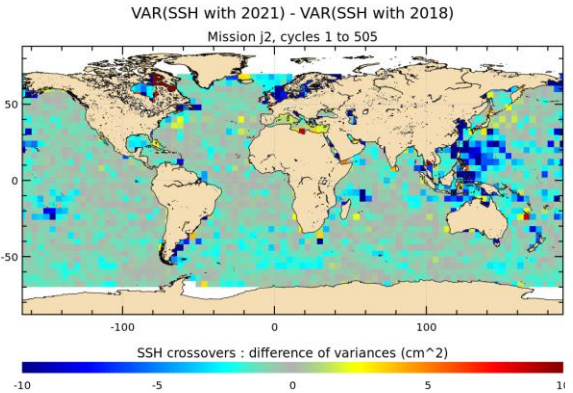


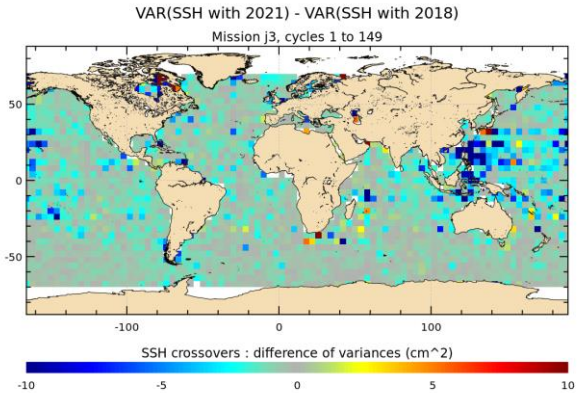


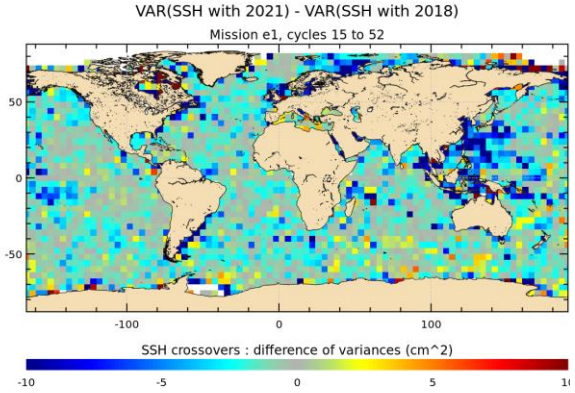
OVERALL IMPROVEMENTS

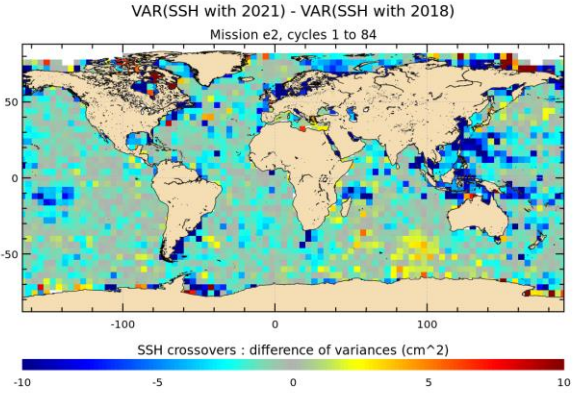


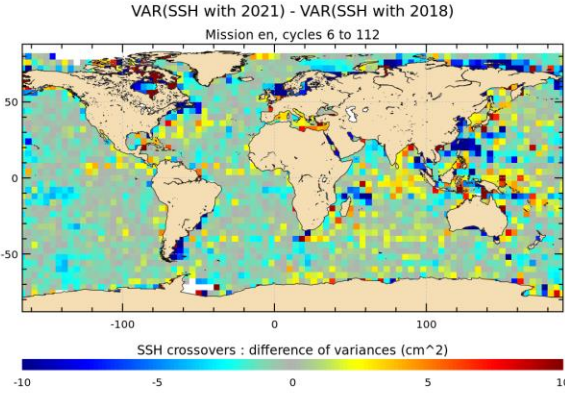


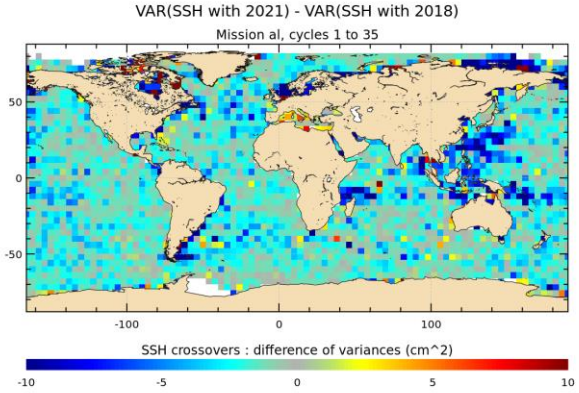


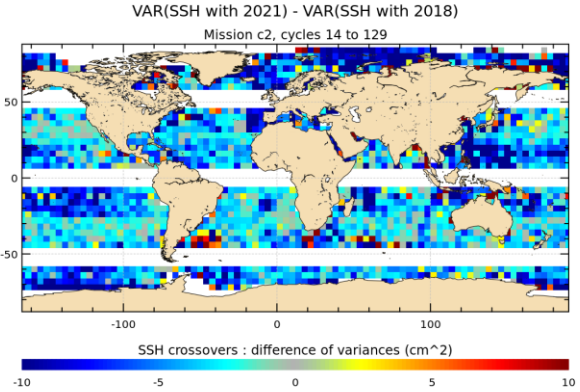


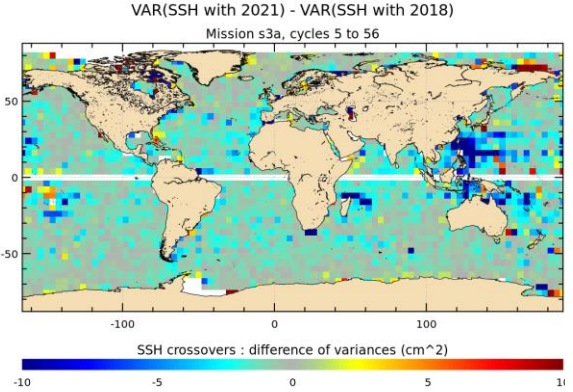


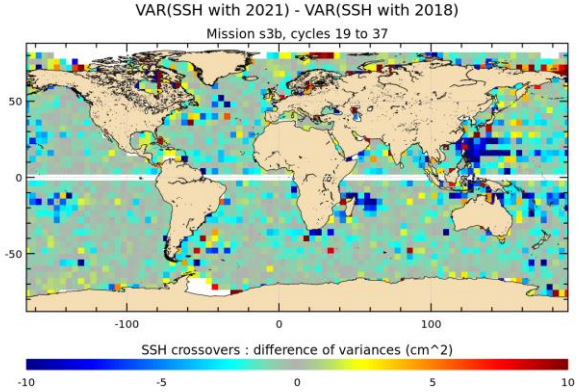










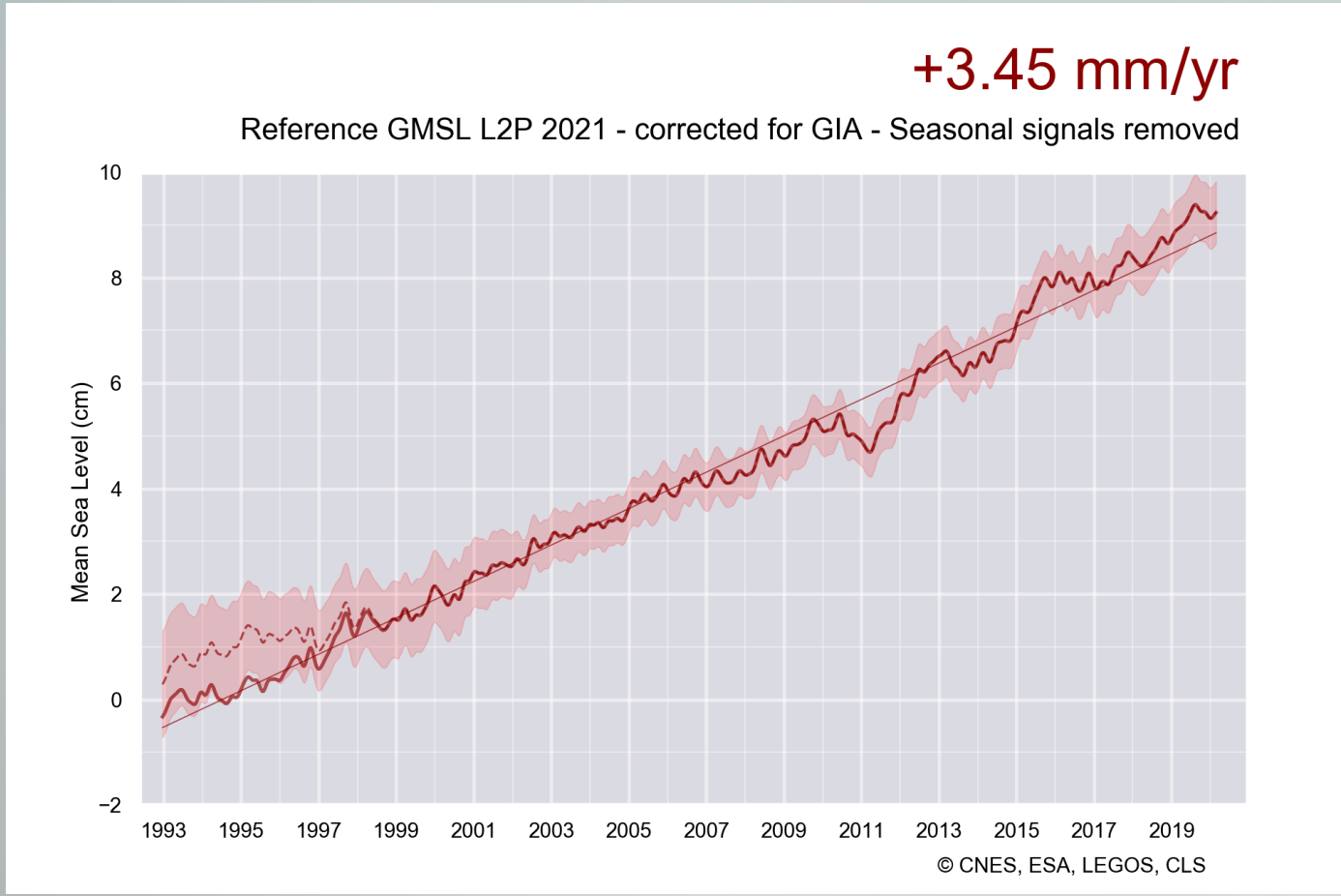


Reduction of sea surface height variance at crossovers (10days) for each mission
Blue = Improvement

GLOBAL MEAN SEA LEVEL

The Global Mean Sea Level (GMSL) of reference (Topex-A/B ; Jason-1 ; Jason-2 & Jason-3) has been recomputed with the new standard L2+ 2021

=> will be soon available on AVISO (end of 2020)



The dashed line corresponds to the suggested correction of Topex-A drift (Cazenave et al, WCRP, 2018)

The global mean sea level rise over the full altimetry era (~27 years) is estimated at +3.45 mm/yr with the use of the new standards of geophysical corrections, similar to the trend derived with the previous L2+ 2018 (+3.42 mm/yr with an uncertainty of 0.4 mm/yr @ 1.65-sigma).

The uncertainty (red envelop) of the GMSL measurements is based on the GMSL error budget of Ablain et al. (2019). The corresponding uncertainty on the GMSL trend is +0.4 mm/yr over the 27 years.

Updates and improvements of the error budget of Ablain et al. (2019) are under investigation, as for the revisit of the inter-mission biases uncertainties (*see Guérou et al., splinter session "Quantifying Errors and Uncertainties in Altimetry data"*)

AVAILABILITY

Download L2P data and handbook on the AVISO+ website
https://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products/global/along-track-sea-level-anomalies-l2p.html

The reprocessed data L2P NTC 2020 V3.0 will be available end of November 2020

COMING SOON in L2P : HY2B mission