Sea Level
Climate
Change
Initiative

SALP Service Altimetrie & Localisation Precise

Improvement of Mean Sea Level trends derived from all the altimetry missions

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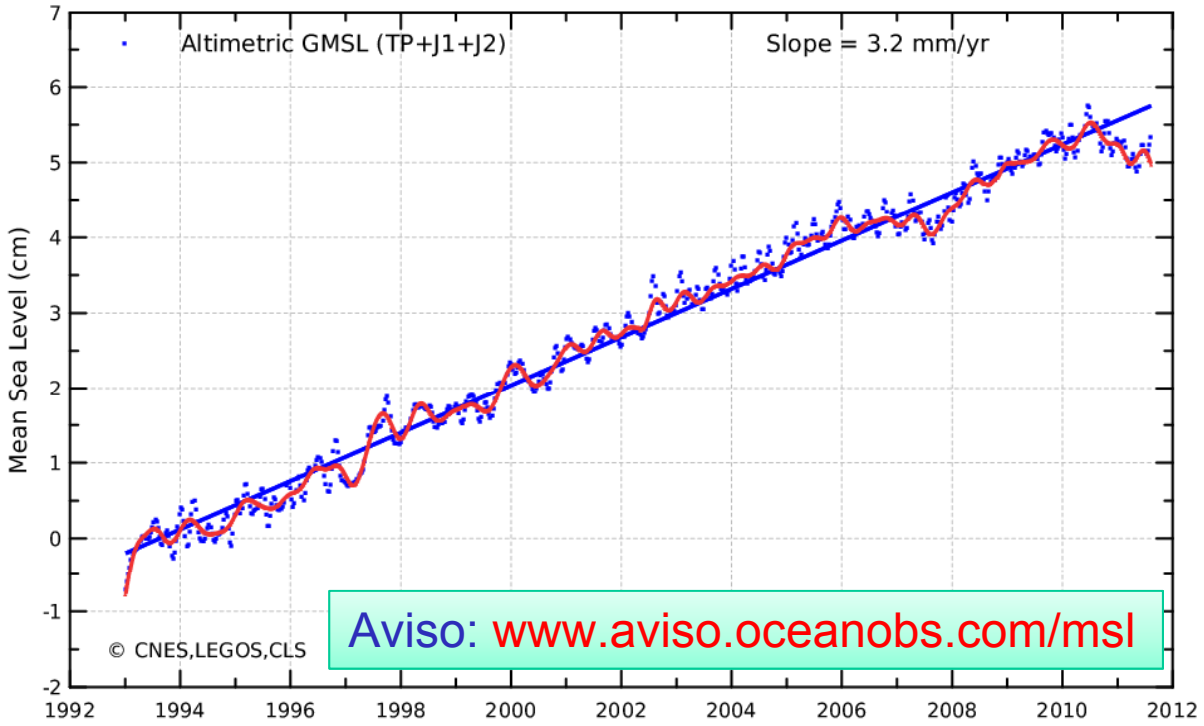
Overview

- From 1993 onwards, the sea level measurements derived from all the altimetry missions provide an accurate climate data record.

- The long-term stability is provided by T/P, Jason-1,Jason-2

⇒ Global MSL trend is 3.2 mm/yr in a confidence interval of 0.6 mm/yr with a probability of 95%

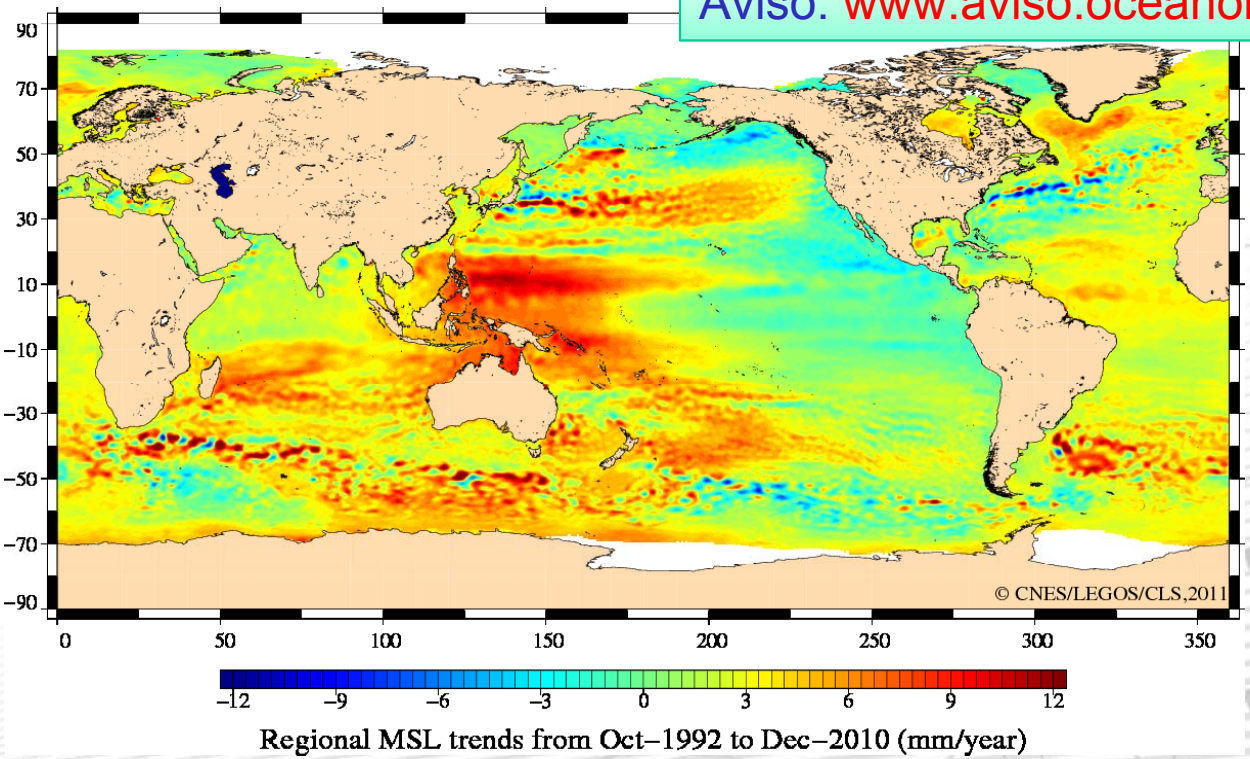


Overview

- From 1993 onwards, the sea level measurements derived from all the altimetry missions provide an accurate climate data record.
- GFO, Envisat, ERS-1 and ERS-2 provide information at high latitudes and also improve the spatial resolution by combining all altimetric missions together.

⇒ The regional MSL trends are calculated with a very high resolution (1/3 of a degree on a Mercator projection)

Aviso: www.aviso.oceanobs.com/msl



Overview

- Global and regional MSL trends are impacted by several source of errors :

⇒ Long-term errors on orbit solutions

⇒ Jumps, oscillations or drifts on wet troposphere correction

⇒ Uncertainties on SSH bias to link altimetry missions together

⇒ Instrumental drift or jump (as the altimeter wind speed for instance)

⇒ Others errors: atmospheric corrections derived from pressure fields, ionosphere correction, sea-state bias, …

- In the frame of the **SALP** project (CNES) and the **Sea-Level CCI project** (ESA), improvements on sea-level calculation are performed :

⇒ to reduce these errors

⇒ to provide an improved Sea-level Climate data record on 2012.

- We focus on the improvements of regional MSL trends through 3 main examples

1) Impact of new CNES orbit solutions on Envisat and Jason-1

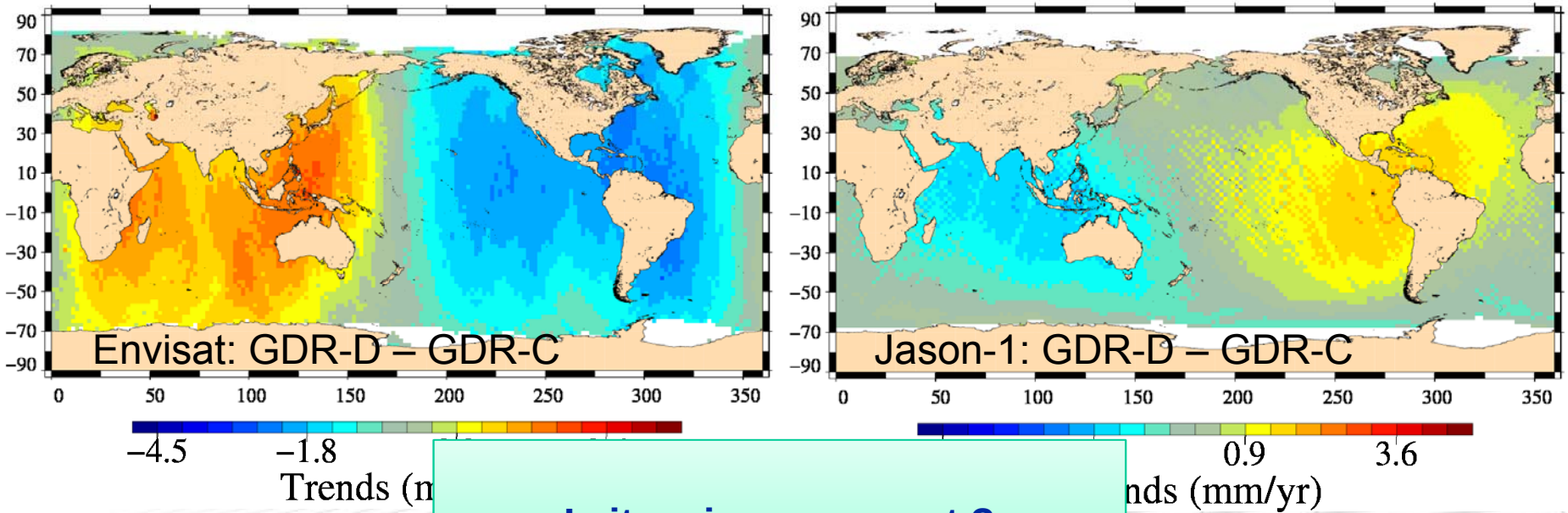
Impact of new orbit solutions: Envisat / Jason-1

- Preliminary CNES GDR-D orbit solutions for Envisat and Jason-1 have been produced taking into account long-term evolution of gravity fields better (see L. Cerri's presentation)

- Their impact for Envisat and Jason-1 is strong on the regional MSL trends :

⇒ ± 4 mm/yr for Envisat from 2003 onwards

⇒ ± 2 mm/yr for Jason-1 from 2002 onwards



Is it an improvement ?

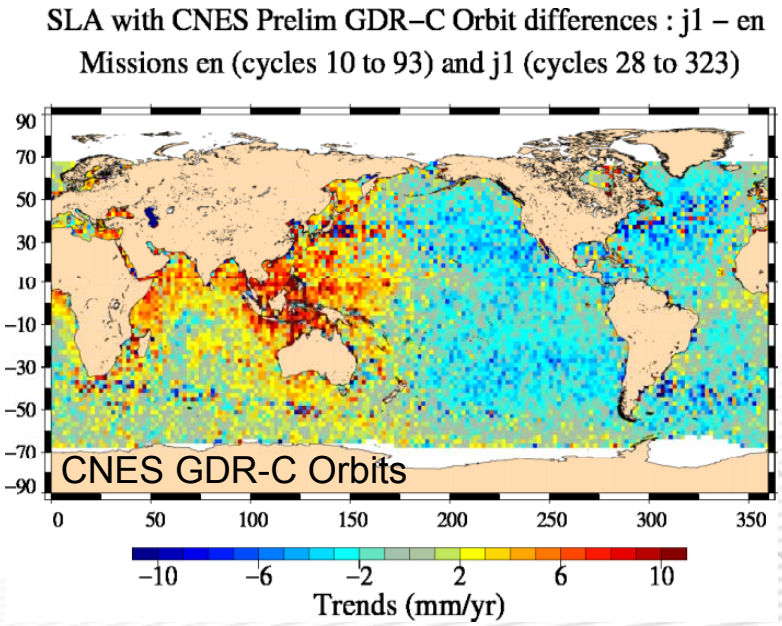
Impact of new orbit solutions: Envisat / Jason-1

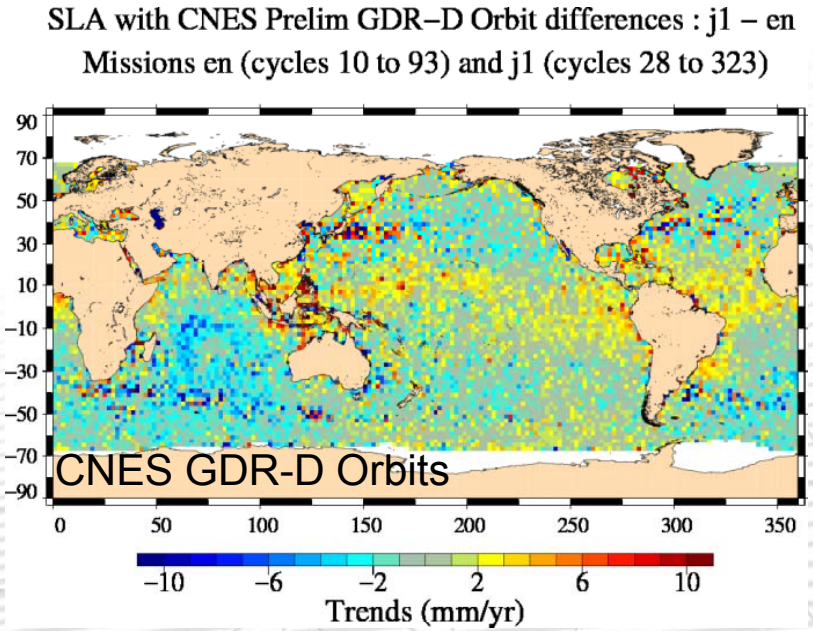
- Strong regional MSL trend differences were observed between Jason-1 and Envisat using CNES orbit derived from GDR-C products: +/- 5 mm/yr

⇒ These large structures are dependant on the longitudes

- Using the preliminary GDR-D CNES orbit solutions:

⇒ The longitudinal differences previously observed are removed





Impact of new orbit solutions: Envisat / Jason-1

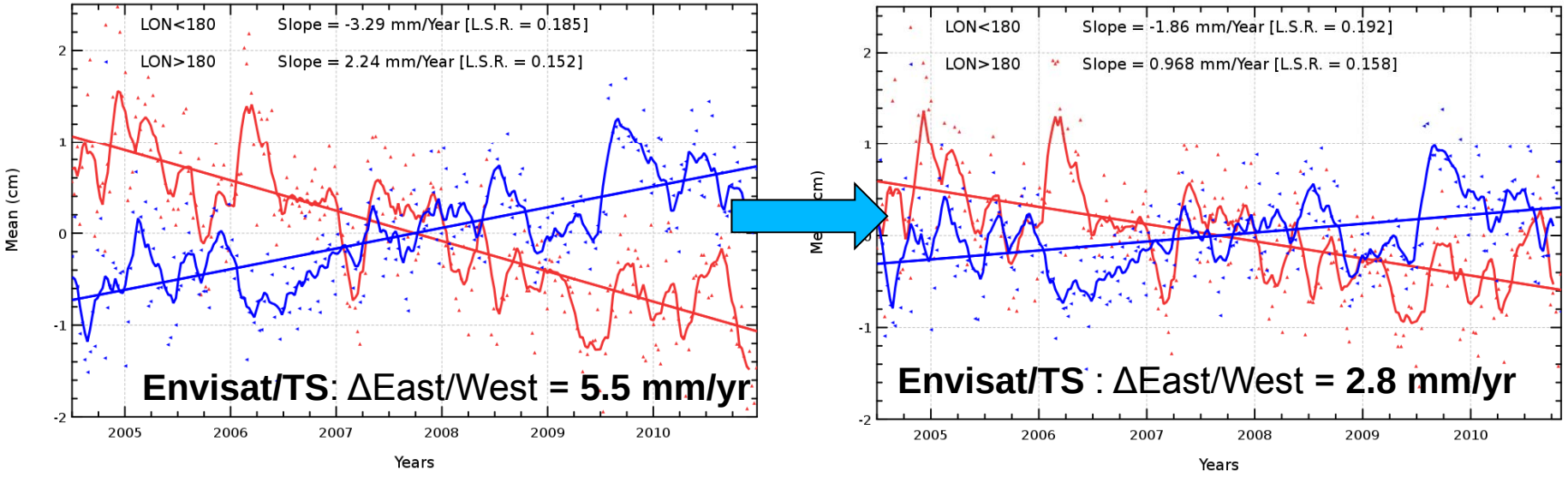
- Comparing MSL derived from Envisat and T/S Argo profiles, we clearly detect strong opposite drifts between the western and eastern part using GDR-C orbits:

⇒ Δ Trend (East/West) = **5.5 mm/yr** instead of **1.1 mm/yr** for Jason-1

- The use of the new CNES preliminary orbit has a strong impact on Envisat:

⇒ the East/West opposite drifts are now reduced to **2.8 mm/yr**

- The residual observed trend difference needs to be investigated.



2) Impact of ERA-interim pressure fields on atmospheric corrections

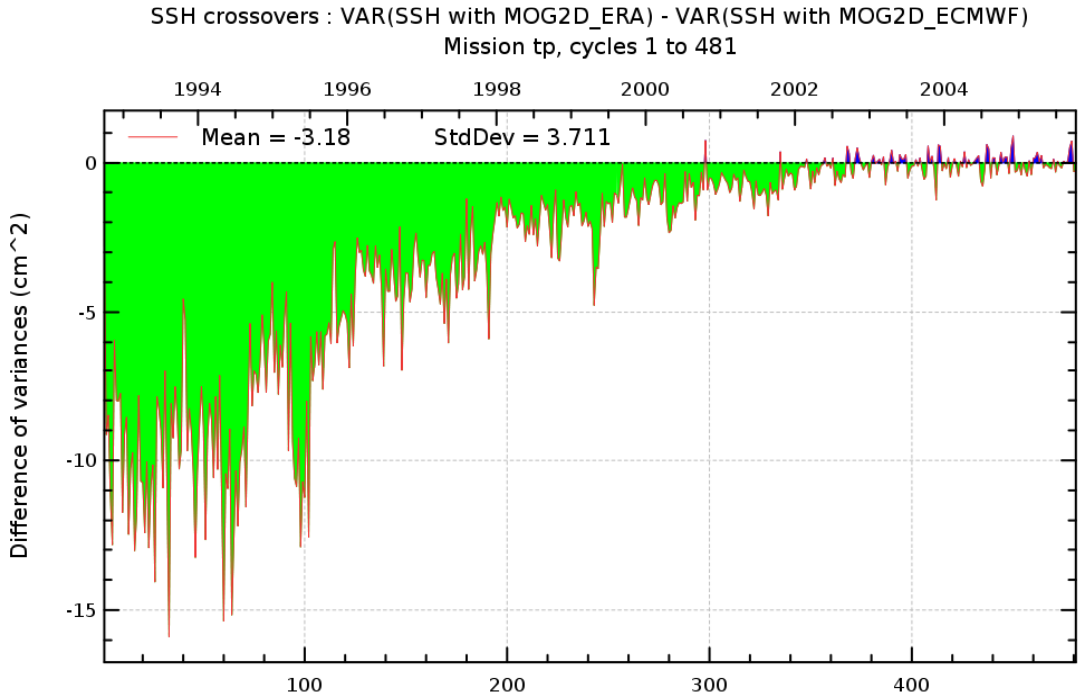
Impact of ERA-interim pressure fields

- New Dynamical Atmospheric Correction (DAC), Inverse Barometer (IB) and Dry Troposphere Correction derived from ERA-interim pressure fields have been calculated

⇒ ERA Interim is the latest global atmospheric reanalysis produced by ECMWF

- These new corrections improved the SSH consistency at crossovers before 2002 (T/P, ERS1&2, GFO):

⇒ SSH variance reduction is higher than 10 cm² using new DAC correction before 1995



Impact of ERA-interim pressure fields

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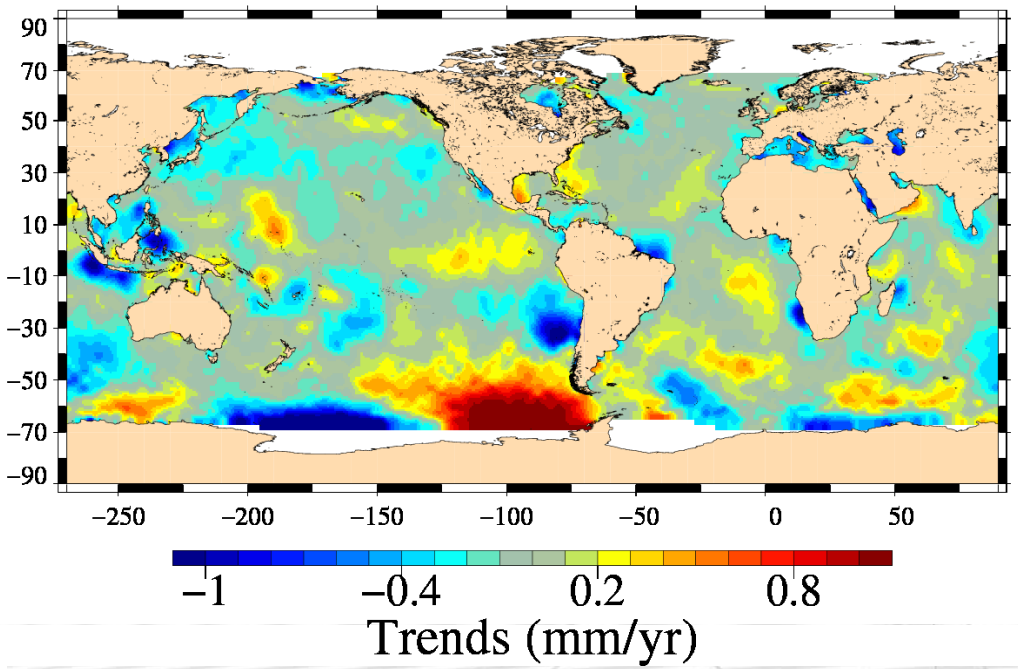
- Such a level of variance reduction has directly an impact on the regional MSL trends:

⇒ ± 1.5 mm/yr MSL trend differences are observed on T/P from 1993 to 2005 using new DAC correction instead of DAC derived from ECMWF operational pressure fields.

SLA with MOG2D_ERA trends – SLA with MOG2D_ECMWF trends
Mission tp, cycles 1 to 481



Impact of ERA-interim pressure fields

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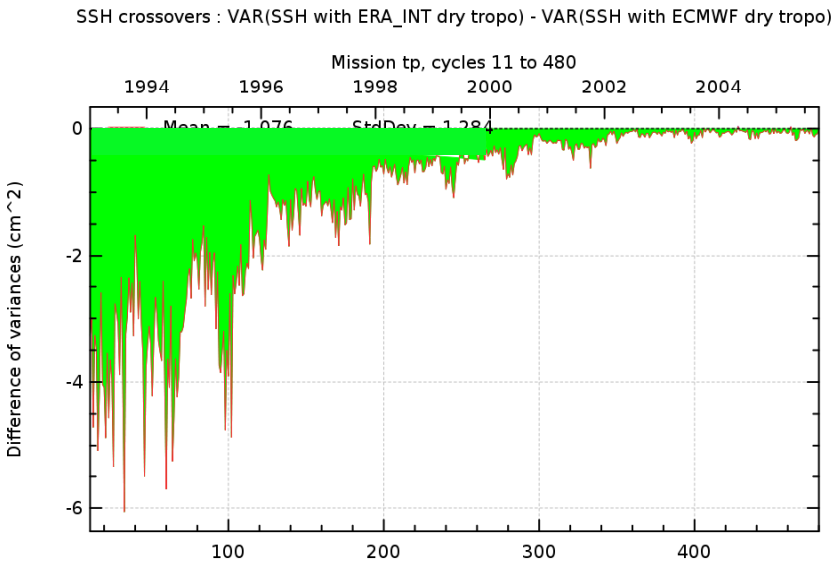
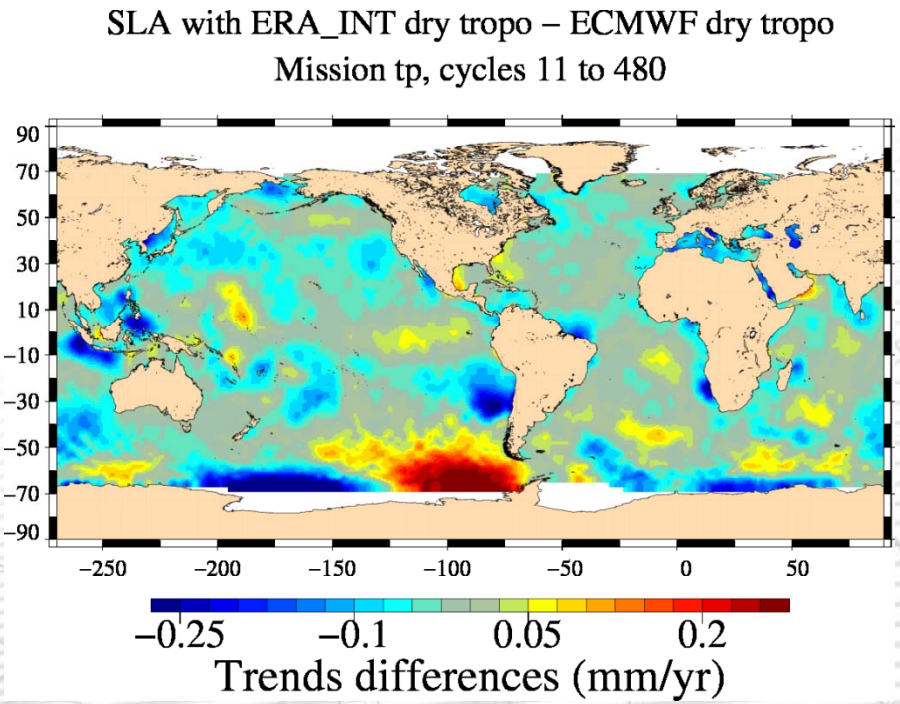
- The impact is lower for the Dry Troposphere correction (± 0.5 mm/yr), but the large structures observed are identical

⇒ The impact of new DAC and Dry Troposphere corrections together can locally reach ± 2 mm/yr on TOPEX period.





3) Impact of regional biases to link T/P, Jason-1&2 together

Impact of SSH regional biases to link altimetry missions together

- A main source of error to calculate the global or the regional Mean Sea Level (MSL) trends is due to the MSL bias uncertainty to link all the altimetry missions together

- Strong efforts have been already done to link together as accurately as possible the global MSL altimetry missions deduced from TOPEX/Poseidon (T/P), Jason-1 and Jason-2:

⇒ Global MSL bias Jason-1 minus TP is 8.45 cm +/- 1 mm

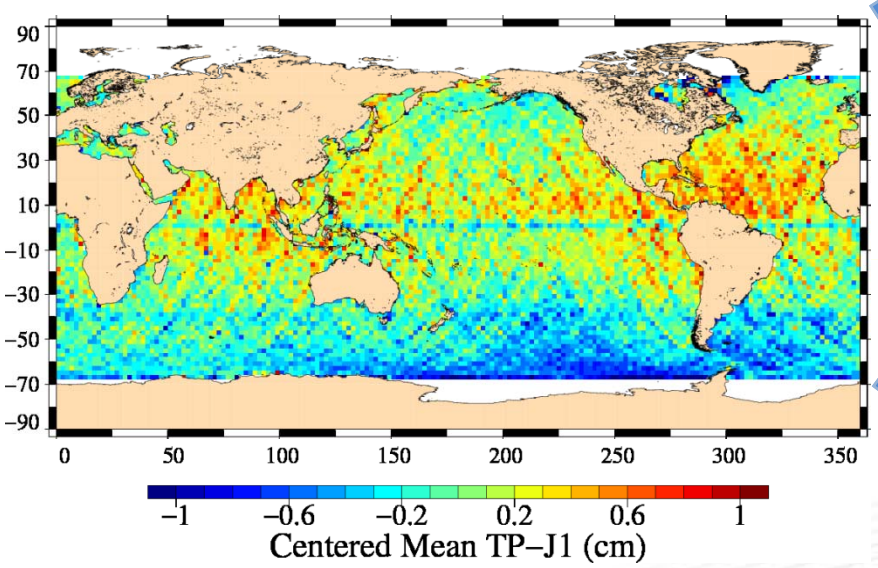
⇒ Global MSL bias Jason-1 minus TP is 7.46 cm +/- 0.5 mm

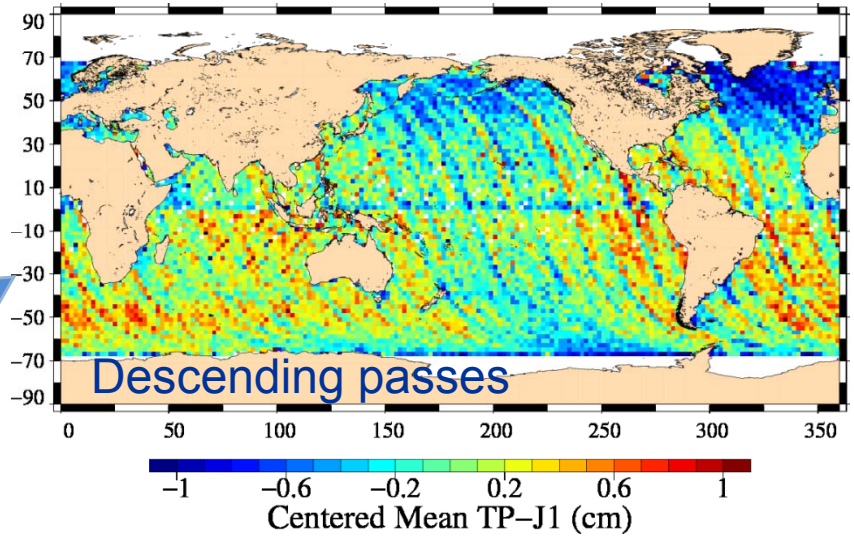
- However, for the regional MSL, systematic geographical biases between altimetry missions have been already detected and not taken into account between TOPEX and Jason-1, and between Jason-1 and Jason-2 (see previous OSTST).

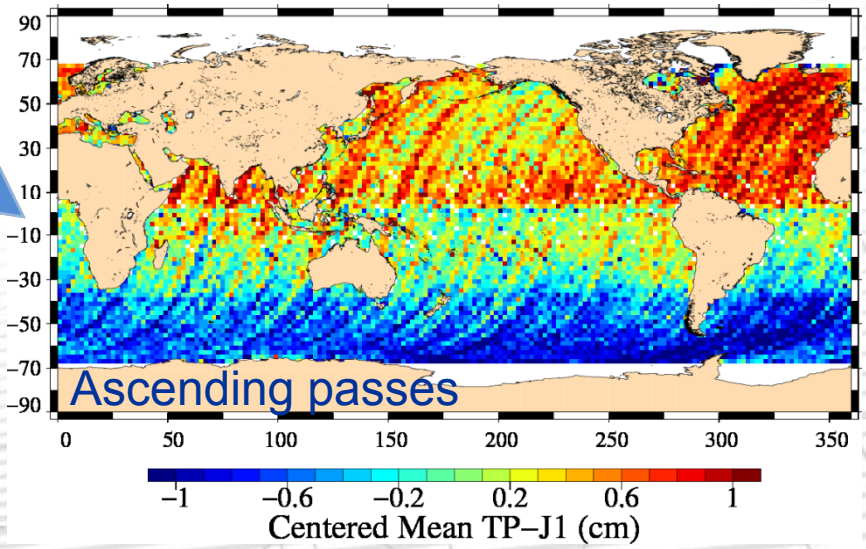
⇒ These errors could impact directly the regional estimation of MSL trends with potential effects higher than 1 mm/yr

Impact of SSH regional biases to link altimetry missions together

Map of SLA differences centered on the average between TOPEX and Jason-1 during the Jason-1 verification phase



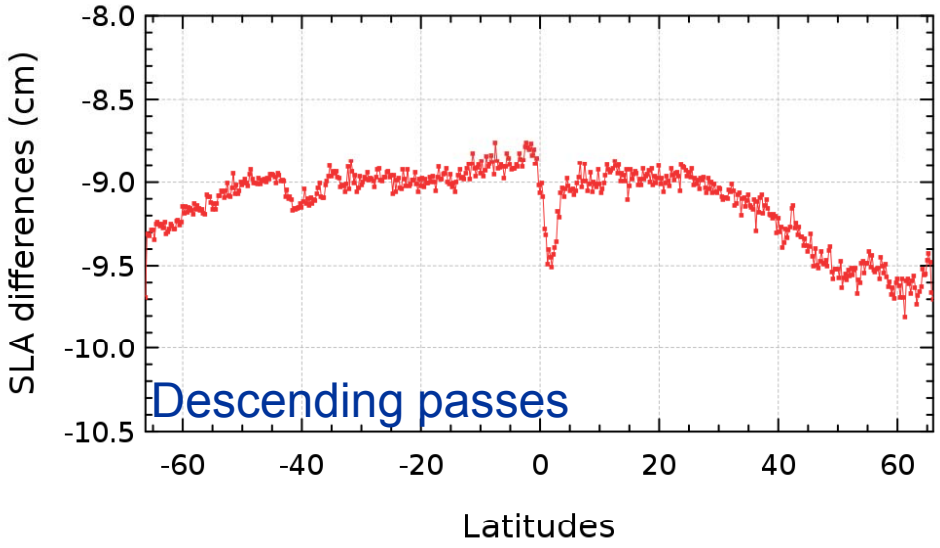


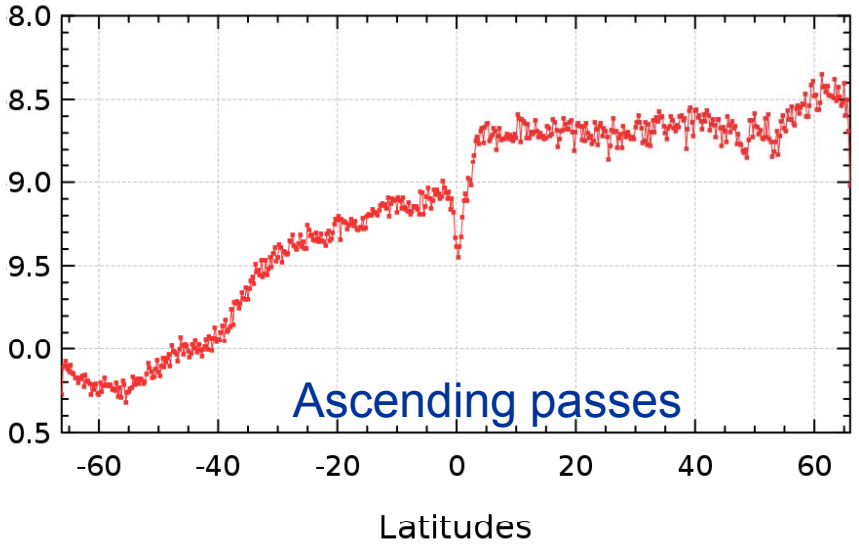


Impact of SSH regional biases to link altimetry missions together

- Objective is to adjust TOPEX-B on Jason-1 in order to remove these systematic effects

⇒ As the SLA differences depend on latitudes, there are averaged by band of latitudes between -66° and +66° separating ascending and descending passes





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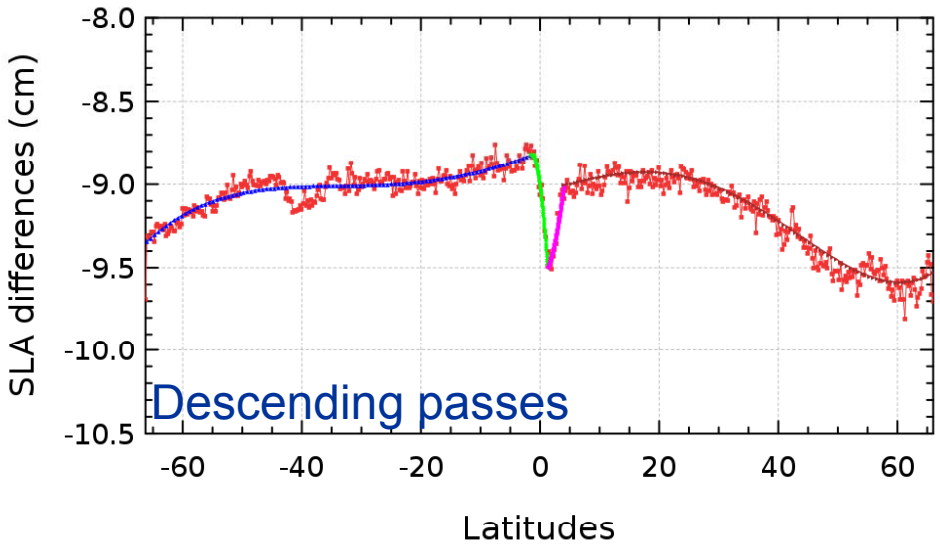
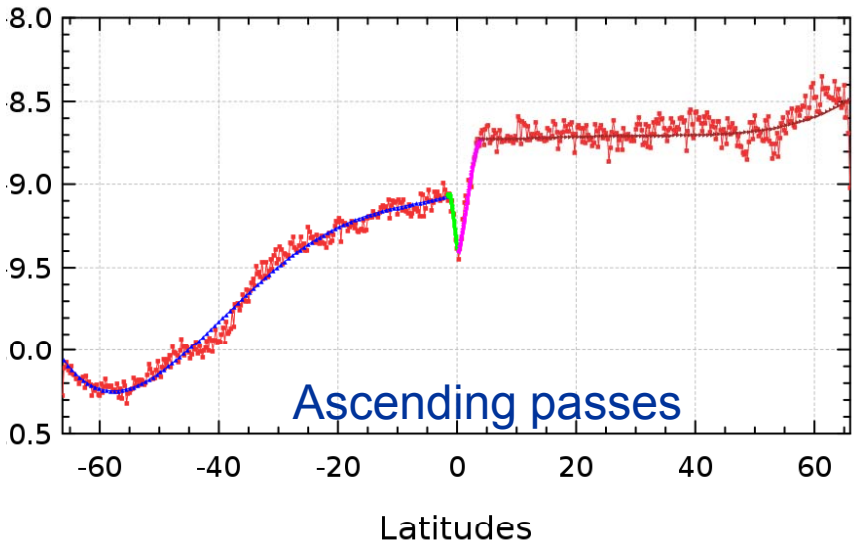
⇒ A polynomial function is adjusted by segment to remove high frequency signals and to take into account the different behaviors of SLA differences





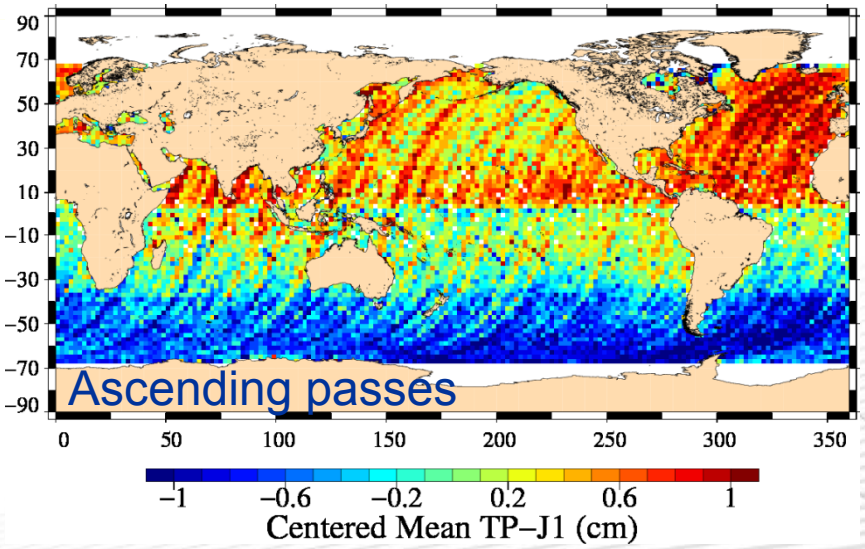
Impact of SSH regional biases to link altimetry missions together

- TOPEX SSH is adjusted on Jason-1 applying these polynomial functions:

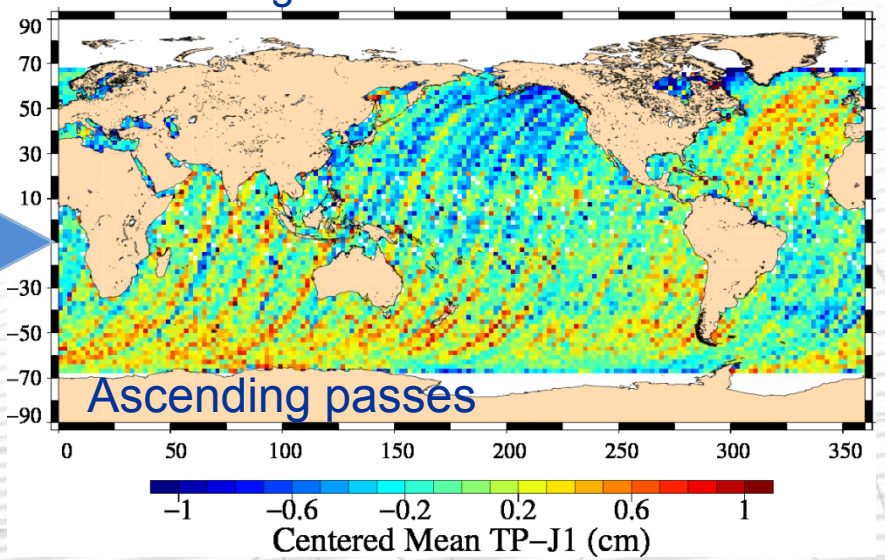
$$SSH_{adjusted} = \begin{cases} SSH - p_{asc}(lat) & for\ ascending\ passes \\ SSH - p_{dsc}(lat) & for\ descending\ passes \end{cases}$$

- Applying these empirical regional corrections on TOPEX data, the regional differences between both missions are strongly reduced

TP-J1 SLA differences before applying the regional bias correction



TP-J1 SLA differences after applying the regional bias correction

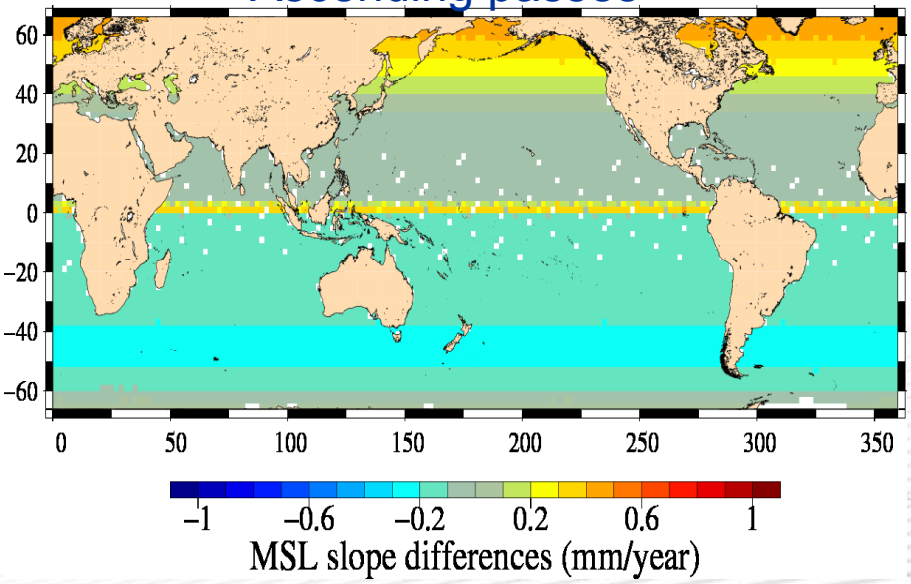


Impact of SSH regional biases to link altimetry missions together

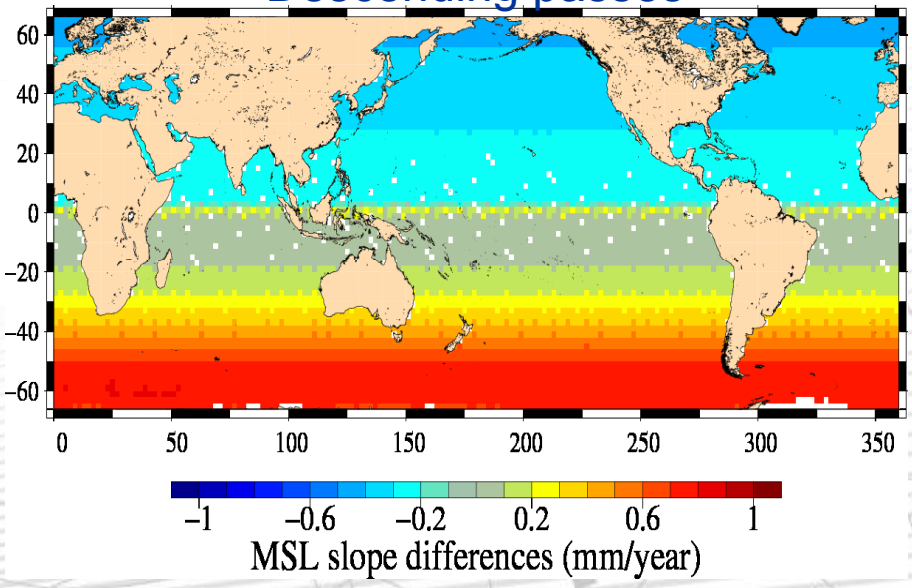
- A similar MSL regional correction has been calculated between Jason-1 and Jason-2 to reduced hemispheric bias observed between both missions (due to orbit calculation)

- Impact on the regional MSL trends has been estimated from 1993 to 2010, linking TP and Jason-1, and Jason-1 and Jason-2 with these new corrections:
  ⇒ It is higher than 1 mm/yr on descending passes.

Ascending passes



Descending passes



Conclusions

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- Thanks to new orbit solutions, new atmospheric corrections and improvement of SSH regional bias, the regional MSL trends are significantly improved

⇒ Impact on TP/Jason-1&2 times series can locally reach 2 mm/yr

- Other corrections have been developed (not shown here) and have also an impact:

⇒ new wet troposphere corrections on coastal areas (see J.Fernandez's presentation)

⇒ new Sea State Bias models (see N.Tran's presentation)

⇒ Improvement of PTR correction on Envisat (see Thibaut's poster)

- Impact on global MSL trend is:

⇒ Low on the TP/Jason-1&2 times series: ~ 0.1 mm/yr

⇒ It is strong considering separately the ERS-1&2/Envisat time series (see Faugere's poster)

- We have already identified remaining errors especially on the first altimetry decade:

⇒ Orbit solutions on T/P and ERS-1&2 do not take into account same gravity fields as Jason

⇒ Instrumental drift or jumps have been detected on TP and not corrected: Sigma0 and SWH drift, SSH regional bias between TOPEX-A and TOPEX-B.

TOPEX reprocessing is needed to improve the climate altimetry data record