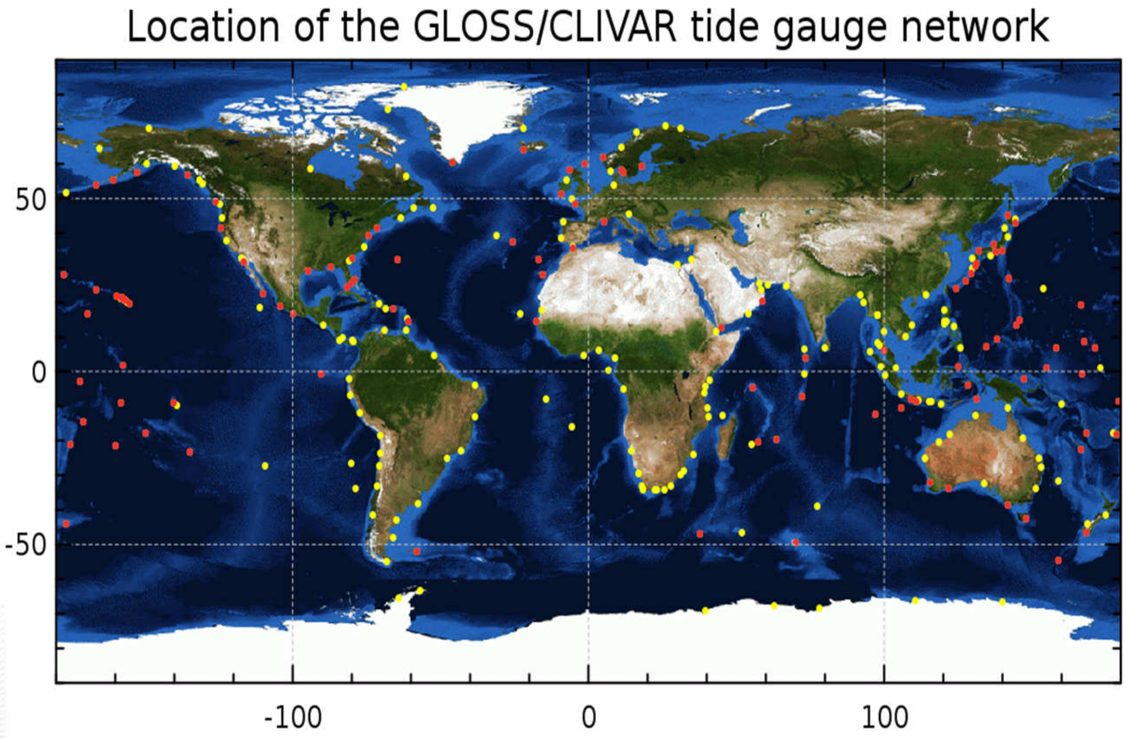
Quality assessment of altimeter and tide gauge data for Mean Sea Level and climate studies

G. Valladeau, L. Soudarin, M. Gravelle, G. Wöppelmann, N. Picot

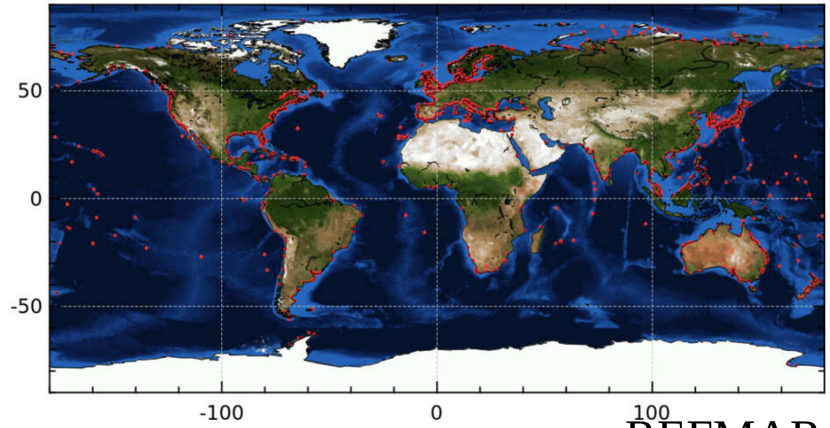
Increasing and improving in-situ datasets

- 2012 -> 1 network: GLOSS/CLIVAR network: 280 Tide Gauges (hourly data) [+ historical SONEL data]

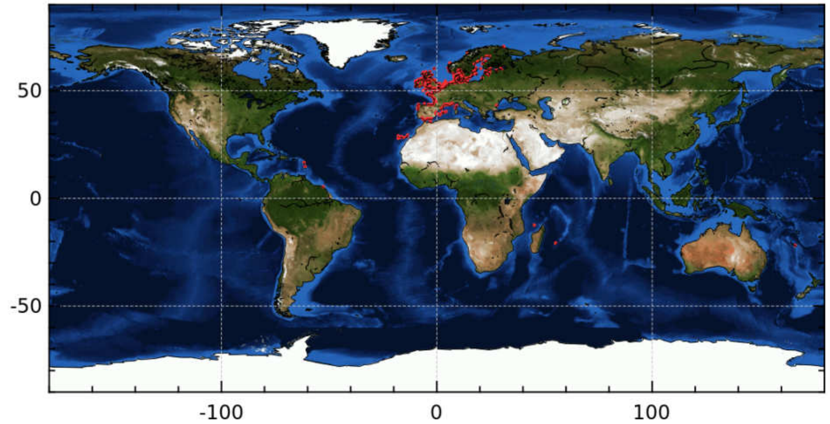
- 2013: PSMSL network: 1316 Tide Gauges (monthly data) -> process ok
  REFMAR network: 309 Tide Gauges (from minute to hourly data)
  -> How to process these data ??



PSMSL

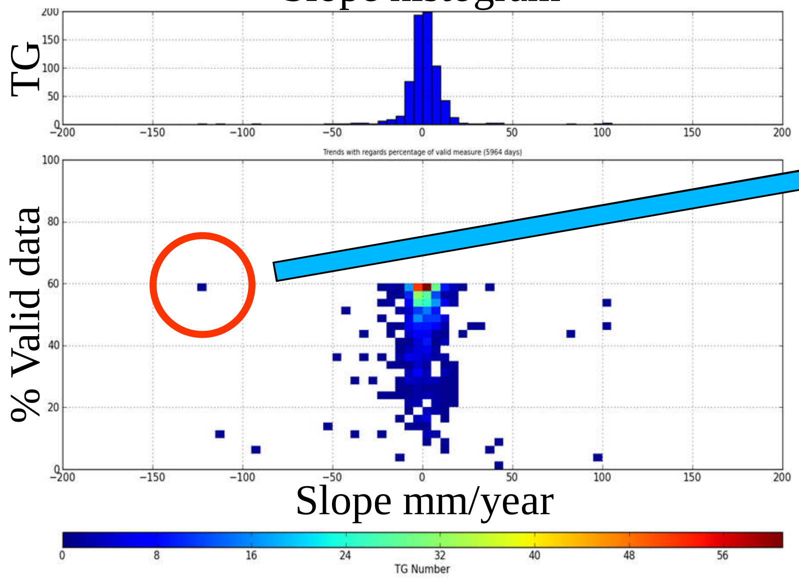


REFMAR

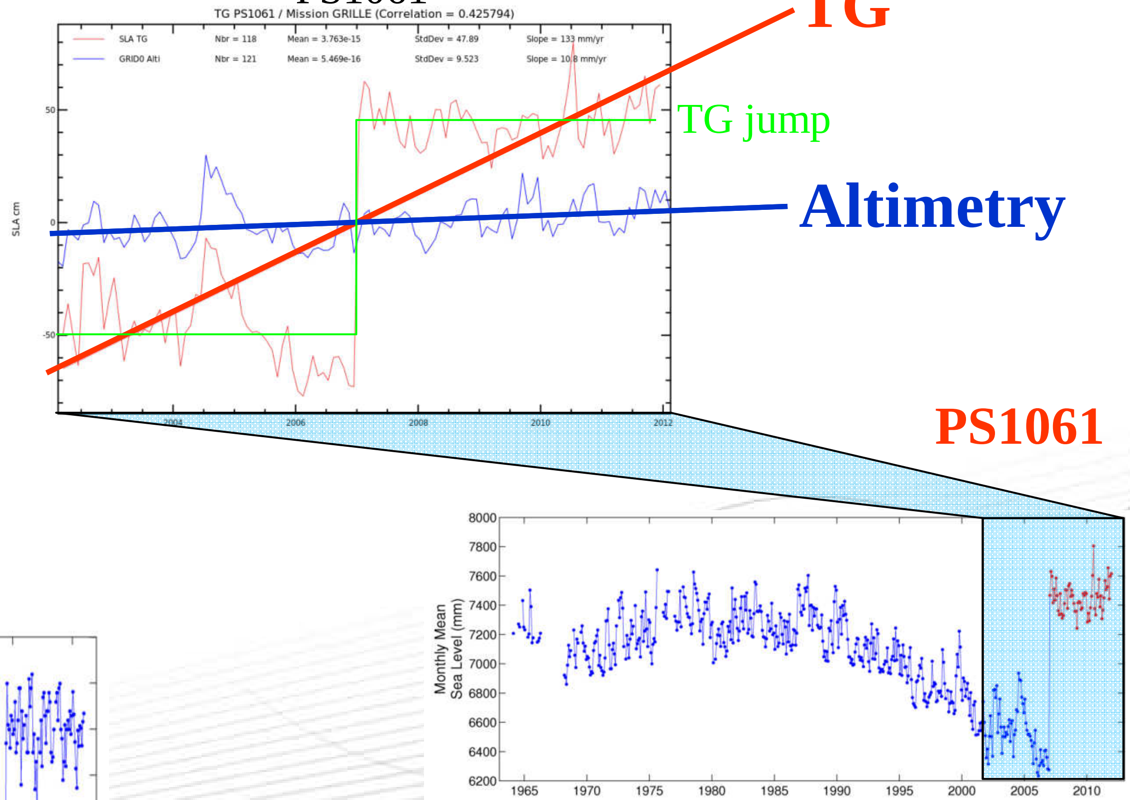


Detection of jumps in tide gauge time series

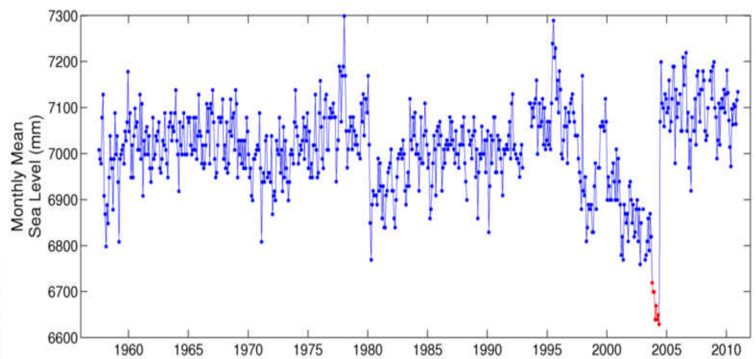
Altimetry– (PSMSL network)
Slope histogram



PS1061



PSMSL flag confirmation **OK**



PSMSL flag **?**

PS0827

Tide gauges spatial sampling

- Action CNES: contacter le SHOM pour numériser des séries temporelles disponibles dans les régions:
  - ✓ Océan indien (partout où il peut y avoir des données: Madagascar, la Réunion, les comptoirs indiens...)
  - ✓ Méditerranée (Maghreb, Liban...)
  - ✓ Sud Est du Pacifique
  - ✓ Océan Austral
  - ✓ Les hautes latitudes

- Réponse SHOM: zones de recherches par priorité:
  - **- Océan Indien**
  - **- Océan Pacifique**
  - **- Océan Austral**
  - - Méditerranée ??

Altimetry/Tide Gauge comparison process

Altimetry: Along-track (level 2) 1 x1 gridded SSH from satellite altimeters, where standards are updated compared with the official Geophysical Data Record (GDR) altimeter products (see AVISO)

- Collocation Method: maximal correlation criteria derived from theoretical altimeter along track products within a 150 km distance circle (Fig. 1)
- Spatial weighting to take into account the non-homogeneous sampling of tide gauges in the whole ocean
- Additional quality controls to compute SSH differences for the most reliable time series

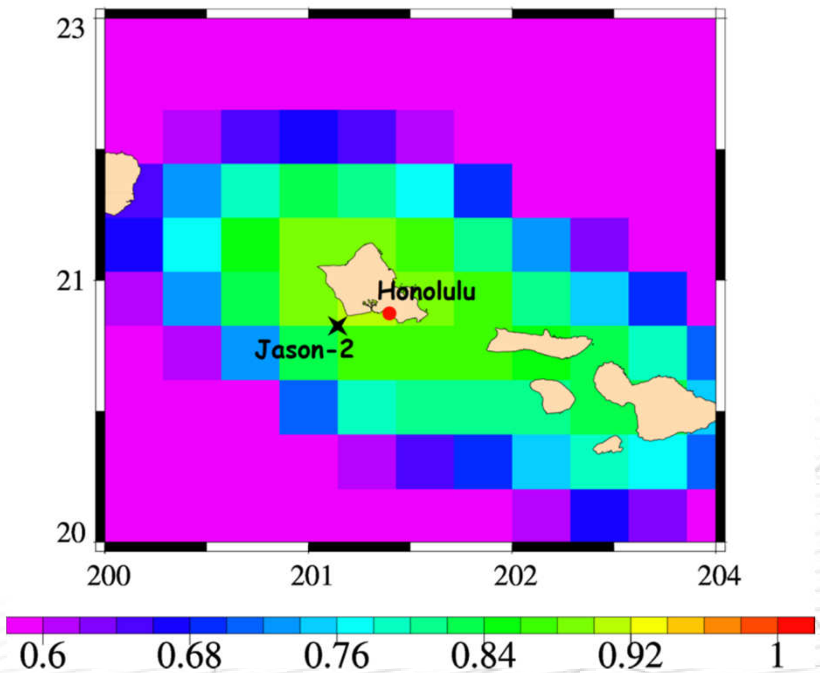


Fig. 1: Computation of the maximum of correlation on Jason-2 from 1/4 x1/4 gridded altimeter products.

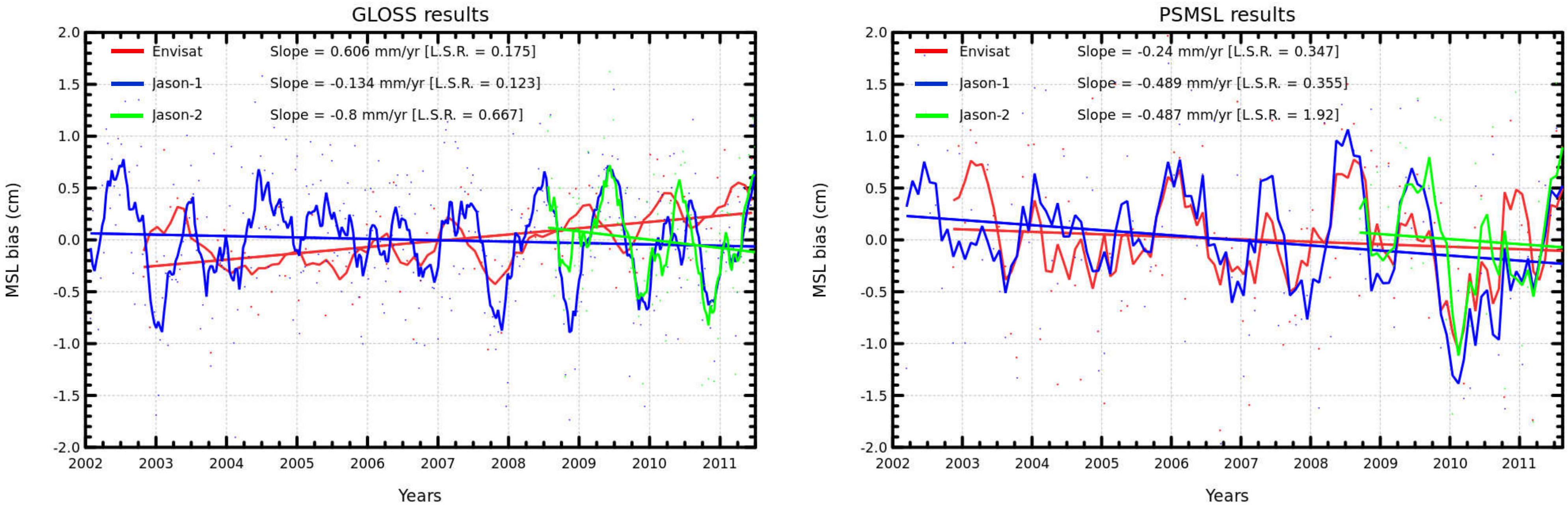
GLOSS / PSMSL results (1/2)

- Comparison between GLOSS/CLIVAR (hourly data) and PSMSL (monthly data) with regard to altimetry

- Trends of MSL differences are consistent for Jason-1&2 between both datasets within the error of the method estimated to 0.7 mm/yr (*Ablain et al., 2009 ; Valladeau et al., 2012*)

- Formal adjustment errors are close between both in-situ datasets except for Jason-2
  -> explained by the short time period considered with monthly in-situ data

- Periodic signals are still to be further studied

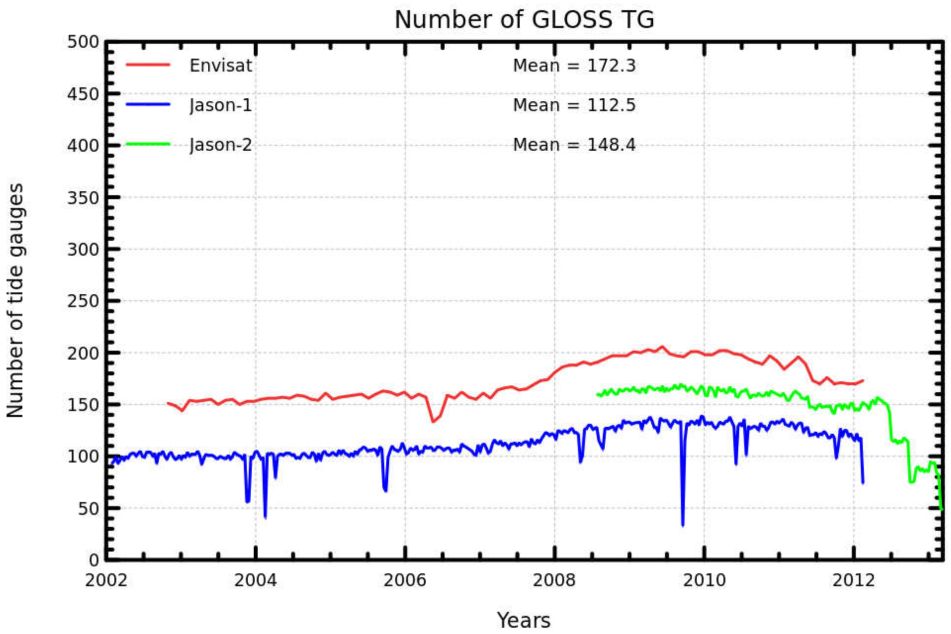


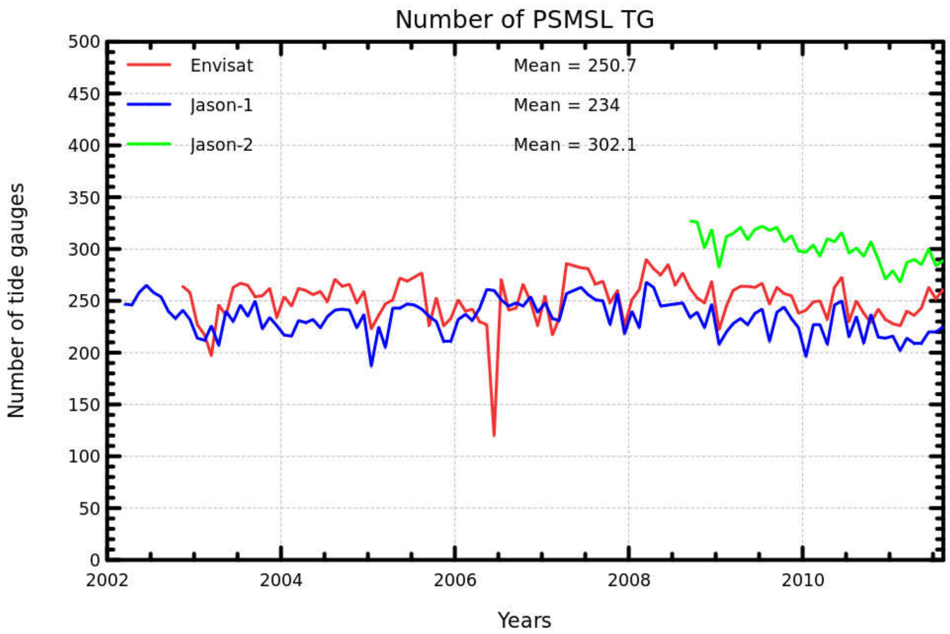
GLOSS / PSMSL results (2/2)

- Number of tide gauges considered between both in-situ datasets

- Considering previous results, the global MSL drift between Altimetry and PSMSL tide gauge data could be more reliable, linked to the number of tide gauges considered

- Further investigations have to be performed to display the real ocean global sampling and see if there are some new areas when processing PSMSL data instead of GLOSS/CLIVAR ones

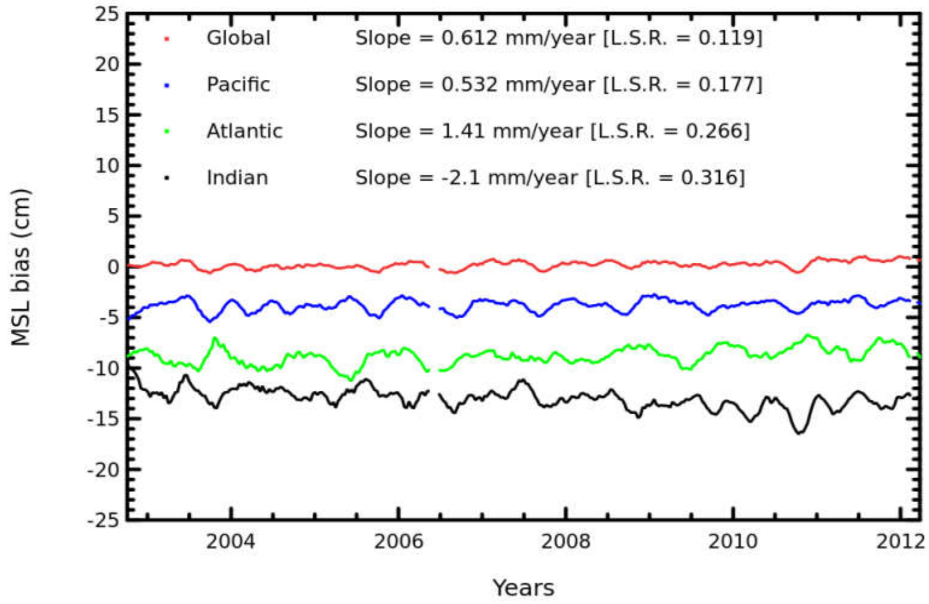




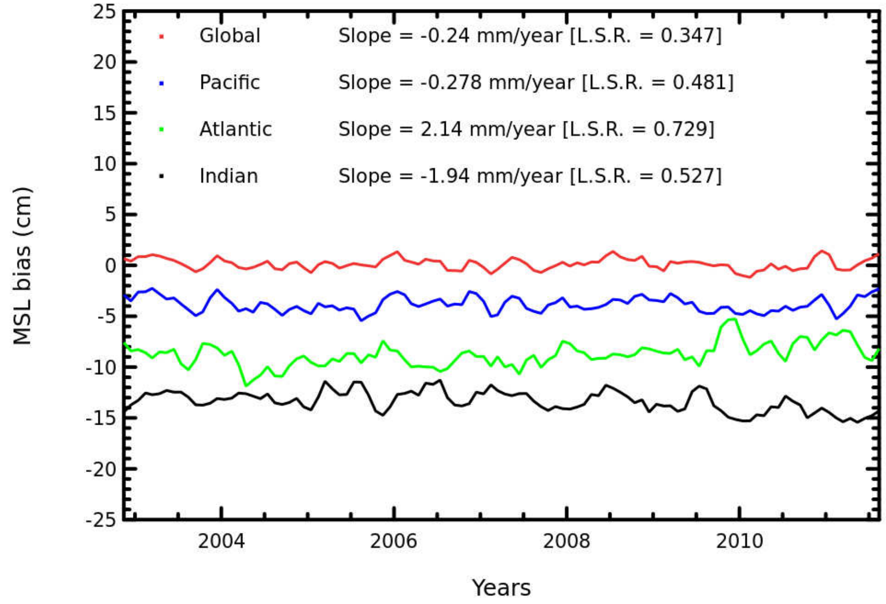
Regional studies

- Homogeneous results between GLOSS/CLIVAR and PSMSL tide gauge networks despite a different spatial and temporal sampling **-> method reliable enough to assess global altimeter MSL drifts as well as the main basins MSL drifts**
- Pacific is the main basin, consistent with global result for PSMSL data
- Atlantic basin not homogenously sampled
- Indian and Mediterranea are poorly sampled -> MSL drift not consistent

GLOSS/CLIVAR

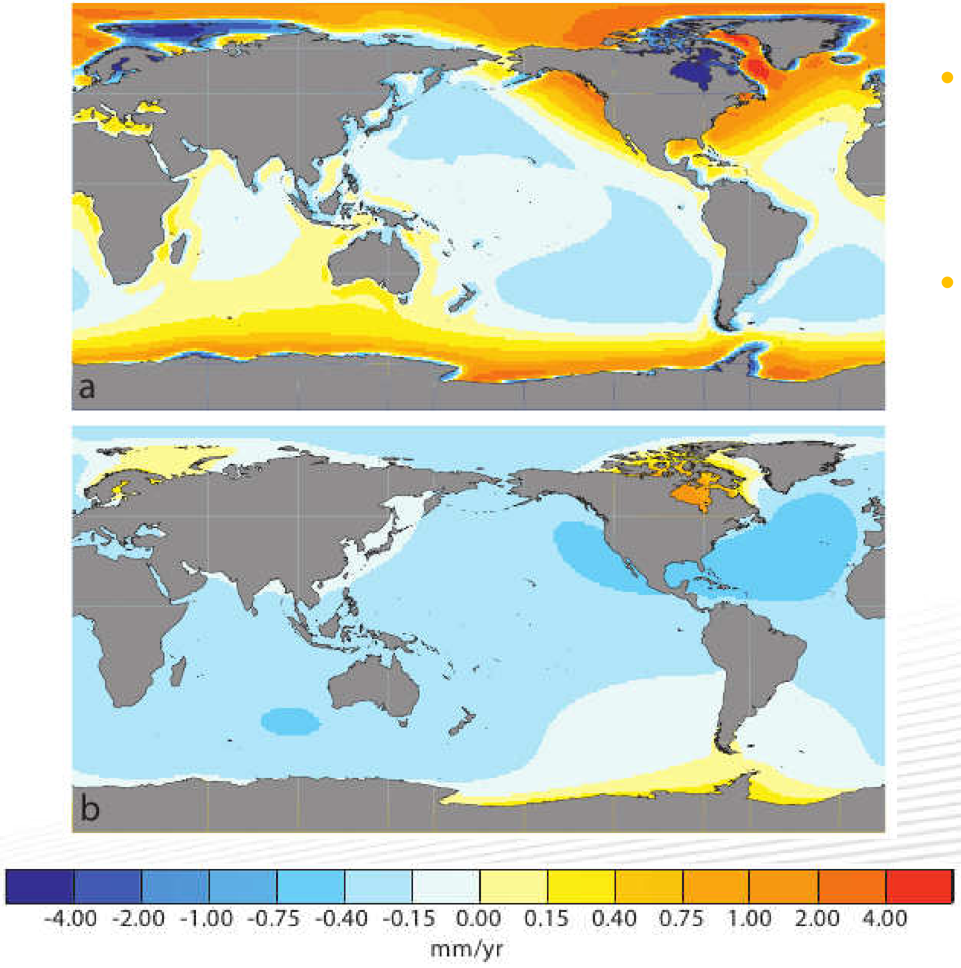


PSMSL



Vertical movements to be considered when comparing altimetry and tide gauges

• **Glacial Isostatic Adjustment** = response of the earth's enveloppes to the mass redistributions following the last deglaciation



- Impact on tide gauges:
  - Vertical crustal motion
  - Geoid changes
  - Basin volume changes
- TG corrected using a model at this time

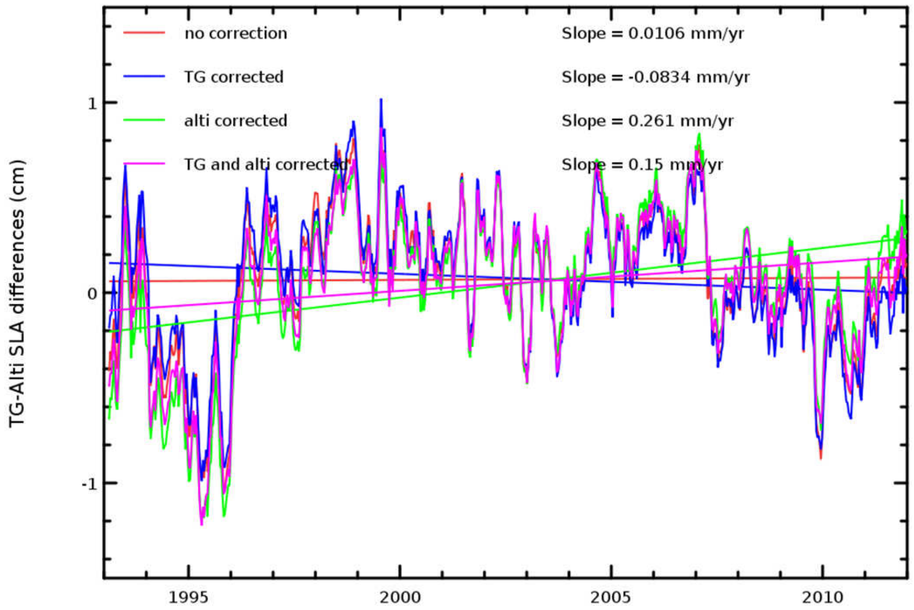
- Impact on altimetry:
  - Geoid changes
  - Basin volume changes
- corrected by applying -0.3 mm/yr to altimetry

➢ **What happens if we use a GIA model to correct altimetry AND TG data ?**

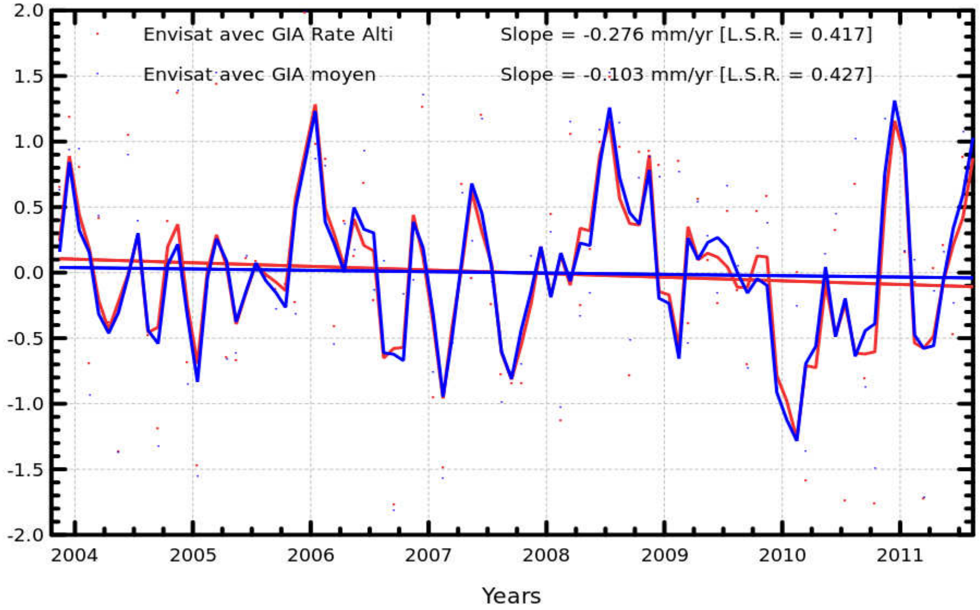
Correcting GIA induced signals

- We use the ICE5G-VM2 model (Peltier, 2004) results
- Standard comparison procedure (Valladeau et al., 2012)

GLOSS/CLIVAR tide gauges (162 stations used)
TP/Jason-1&2 merged altimetry
(19 years of consistent altimetry data)



PSMSL tide gauges (252 stations)
ENVISAT along-track data
(1x1 gridded products)



- Impact is low on the global mean differences trend

How to combine multiple techniques to provide reliable in-situ time series for climate applications (1/2)

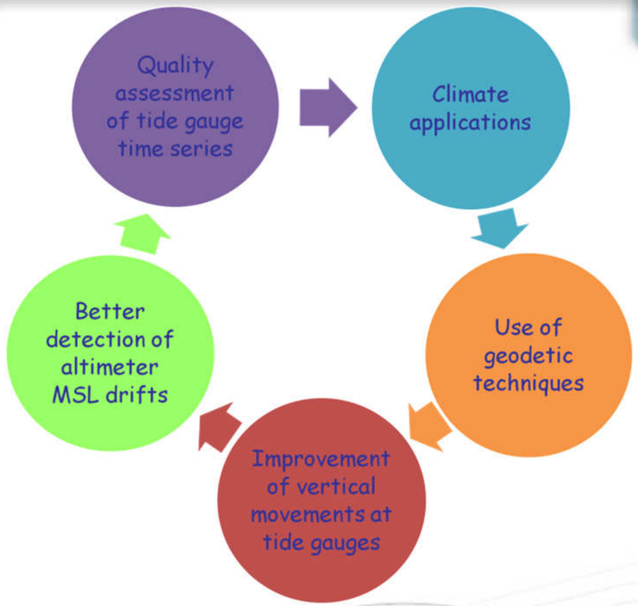
➢ Tide gauge measurements require a rigorous quality control since measurements are highly sensitive to biases or drifts in datasets, especially vertical movements

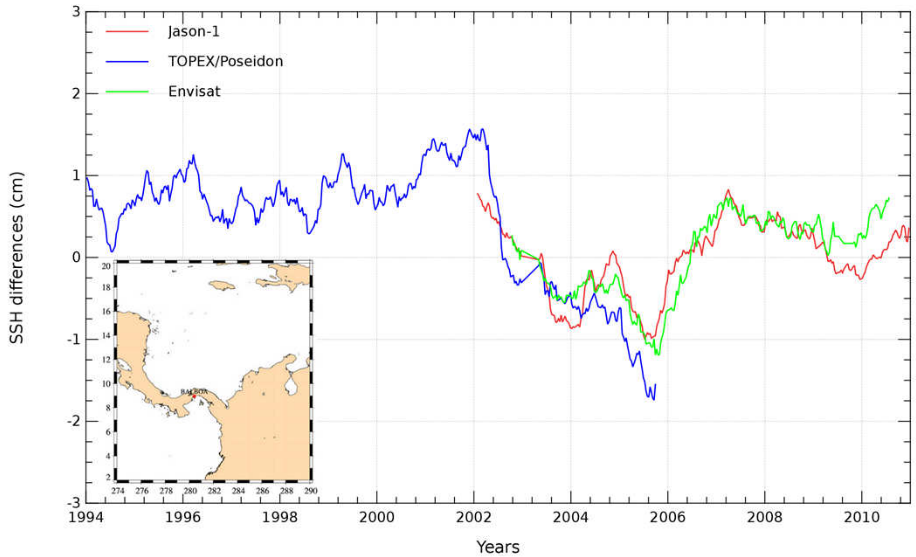
➢ The combination of multiple techniques is a way of providing relevant tide gauge time series for end-users and climate applications (2012 AGU Fall Meeting, poster)

➢ In this study, DORIS and GNSS are considered as complementary techniques to accurately determine the crustal motion at a cm (or better) and mm/yr accuracy for th positions and velocities

➢ Cross-comparison of altimeter and in-situ SSH differences from all altimeter missions (Jason1&2, Envisat and TOPEX/Poseidon)

➢ Used to select relevant tide gauges for altimeter/in-situ comparisons from the 3 main missions, Jason-1, TOPEX/Poseidon and Envisat





How to combine multiple techniques to provide reliable in-situ time series for climate applications (2/2)

- Comparison of vertical movements deduced from both ULR5 GPS solutions and lca11wd02 DORIS solutions performed by CNES-CLS

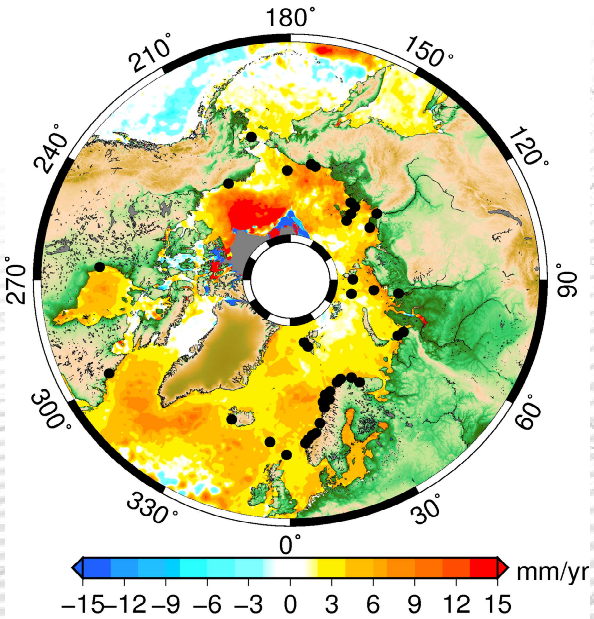
- Computation of linear trends on tide gauge time periods and calculation of the uncertainties with the CATS software (GPS coordinate time series analysis software)

- On 10 tide gauge sites colocated with GPS and DORIS stations (distance < 15 km), differences are lower than 3σ -> GPS and DORIS velocities are coherent with each other

Tide Gauge name (Time Period)	Tide Gauge trend (mm/yr)	Colocated Envisat trend (mm/yr)	Colocated DORIS trend (mm/yr)	Colocated GPS trend (mm/yr)
Ponta Delgada (2002-2011)	11.9 +/- 0.54	-3.86 +/- 0.92	-3.16 +/- 0.60	-1.46 +/- 0.17
Thule (2007-2011)	-20.2 +/- 3.2	-16.7 +/- 7.66	9.32 +/- 1.24	8.21 +/- 0.32
Easter Island (2004-2010)	-1.97 +/- 0.06	0.42 +/- 0.26	0.15 +/- 0.90	-0.43 +/- 0.25

- Altimeter datasets can be validated thanks to tide gauges which provide independent sea level data

- New dataset of weekly gridded sea level anomaly fields over the Arctic region from 1993 to 2009



Visualization/Extraction tool for Altimetry/Tide Gauges/Geodesy time series