ESA Climate Change Initiative

Sea-level-CCI project

A.Cazenave (Science Leader), G.Larnicol /Y.Faugere(Project Leader), M.Ablain (EO)

MARCDAT-III meeting - Frascati, Italy - May 2011

Sea-level: an indicator of climate change

- Sea Level is a sensitive index of climate change and variability:

⇒It responds to change of ALL components of the climate system (ocean, atmosphere, cryosphere, hydrosphere) and even to solid Earth processes (GIA).

⇒Satellite and in situ observations indicate that sea level is currently rising. It will continue to rise in the future decades : But how much? We don't know…..

⇒ Coastal impacts of sea level rise are among the most threatened consequences of global warming

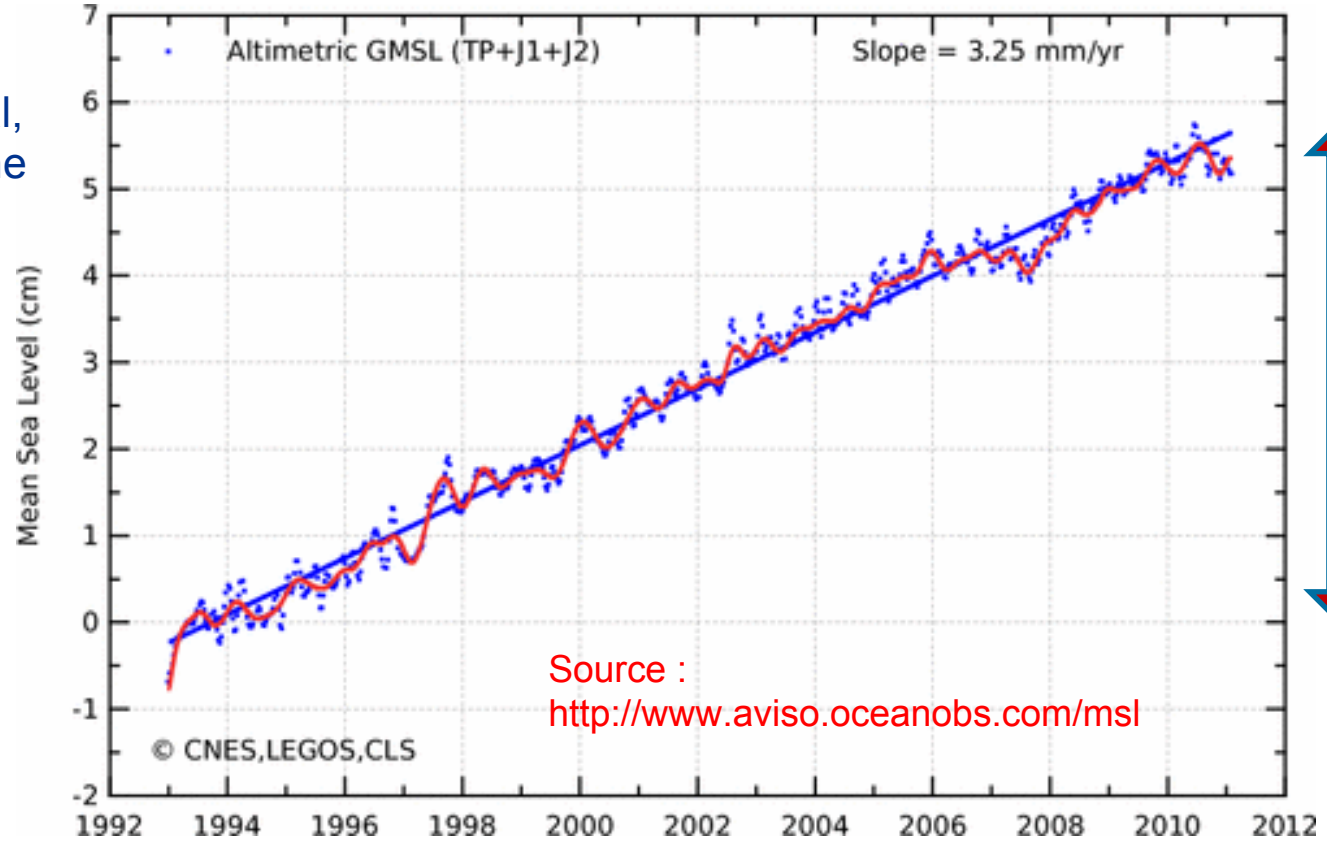
⇒ Coupled climate models neither provide yet reliable sea level projections nor reproduce adequately 20th Century sea level rise.

⇒ Accurate monitoring of sea level change (globally and regionally) by Satellite altimetry (multi-missions) is a high-priority objective.

Global Mean Sea-level evolution

- The global MSL evolution deduced from the altimetry missions is calculated from 1993 onwards

- After removing annual, semi-annual signals, the GMSL trend is 3.25 mm/yr (with GIA) from January 1993 to December 2011



Regional Mean Sea-level evolution

- The regional MSL trends are estimated from multi-mission grids (AVISO products) using all the altimetry missions available.

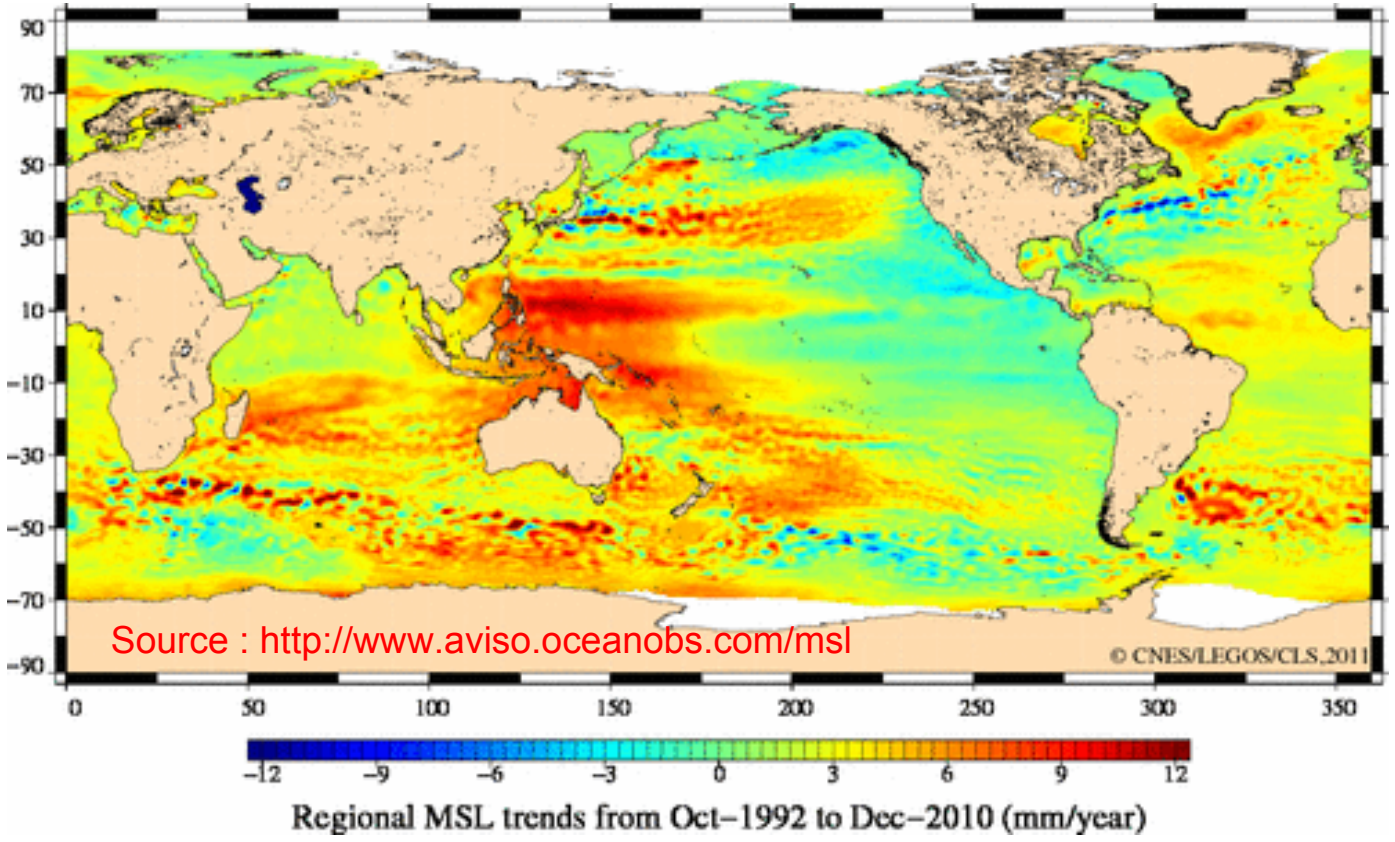
- Inhomogeneous repartition of the ocean elevation is highlighted : +/- 10 mm/yr

⇒Mainly due to the inter-annual variability of the ocean

- ESA missions (Envisat, ERS-2) allow us to:

⇒compute MSL at high latitudes (higher than 66°N and S)

⇒ improve the spatial resolution



Regional MSL trends from Oct–1992 to Dec–2010 (mm/year)

Error of global MSL trend

• The confidence on the global MSL trend is good :

⇒ 3.25 mm/yr **+/- 0.6 mm/yr** in a confidence interval of **90%** (Ablain et al, 2009)

• The main sources of errors concerning the global MSL stability are :

⇒ the wet troposphere correction : +/- 0.3 mm/yr

⇒ the orbit calculation : +/- 0.15 mm/yr

⇒ the bias uncertainty to link the altimetry missions together : +/- 0.2 mm/yr

⇒ the altimeter parameters : +/- 0.1 mm/yr

⇒ the atmospheric corrections : +/- 0.1 mm/yr

The GCOS requirement concerning the global MSL stability is 0.3 mm/yr

⇒ It is not reached at the moment

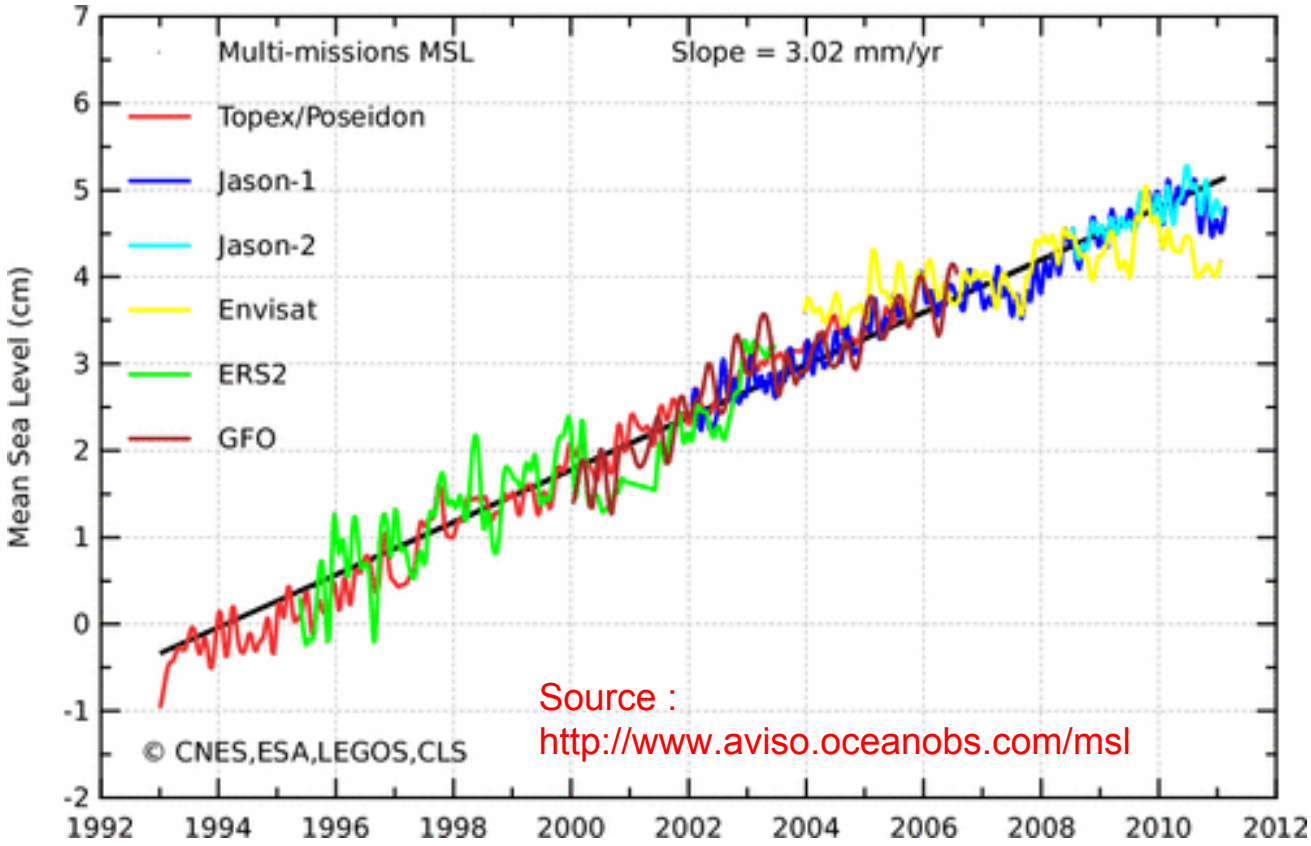
Error of global MSL trend

• Plotting separately the MSL derived from all the altimetry missions allows us to show a good agreement between all the missions (MSL increases for all the missions)

• However, differences are observed:

⇒Envisat MSL trend is lower : 1 mm/yr instead of 3 mm/yr in average

⇒ differences of 5 mm at annual scale are detected between T/P and ERS-2, and between GFO and T/P / Jason-1.



Drift of altimetry MSL time series

• In order to measure the drift of each altimetric MSL time series, in-situ measurements are used :

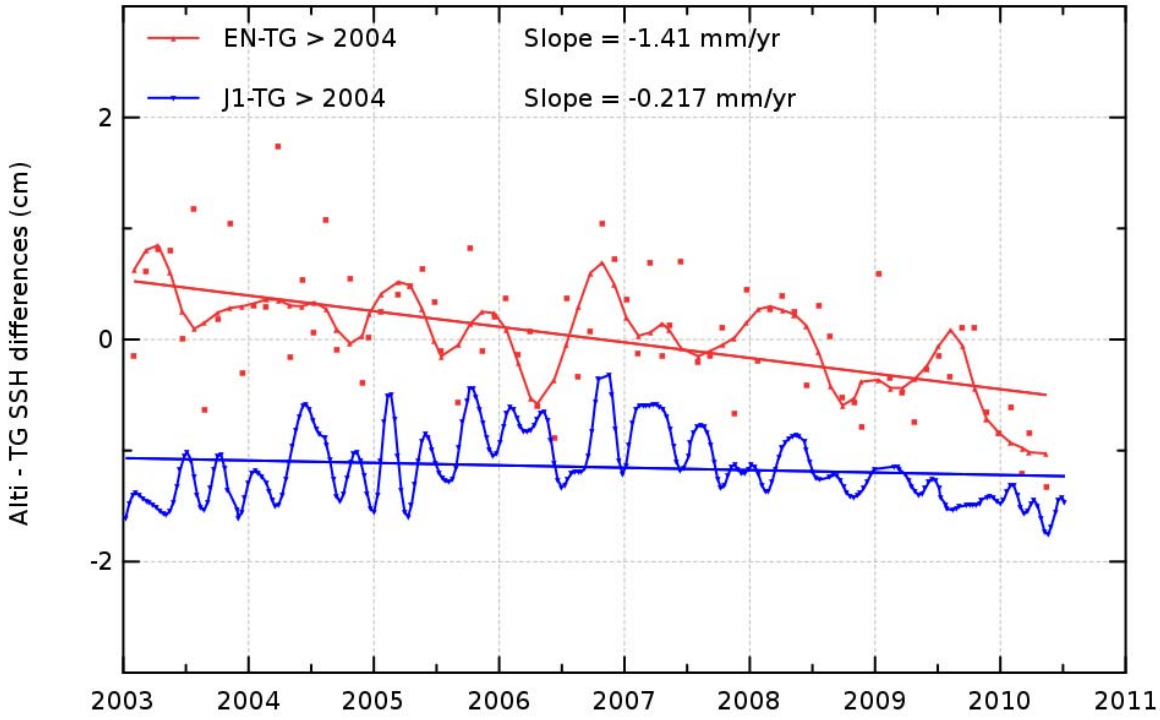
⇒ Global tide gauges networks

⇒ Salinity profiles (ARGO)

• Example: using tide gauges, a significant negative drift on the global Envisat MSL is displayed :

⇒ Envisat/TG = -1.4 mm/yr

⇒ Jason-1/TG = -0.2 mm/yr



One of the main objective of the CCI project will be to improve the sea-level calculation for all the altimetry missions especially in terms of long-term stability

Sea-level-CCI objectives

• The main goal of the project is to provide « Sea level » ECV product to the scientific community

•The sea-level ECV products derived from all the altimetry missions will contain :

⇒ Time data series of sea level anomaly (SLA): it corresponds to the global and regional time data series:

- Global MSL: 1-dimension vector of monthly average SLA
- Regional MSL: 2-dimension grids of monthly SLA grids calculated after merging all the altimetric mission together.

⇒ Oceanic indicators: it corresponds to statistic information estimated over all the altimeter period from the SLA time data series. Several indicators are provided as the trend of the global and the regional MSL, the amplitude and phase of the main periodic signals (annual, semi-annual)

⇒ Errors of oceanic indicators: it corresponds to the errors of the oceanic indicators (error on the global MSL trend for instance).

Sea-level-CCI objectives

In order to generate the ECVs products, the objectives of the project are :

1)To involve the Climate research community which is the main user of the Sea Level ECV to improve the understanding of their needs and thus ensure a perfect consistency between the need and the future development and improvement of the altimeter processing system

2)To improve the sea-level calculation for all the altimetry missions : to develop, test and select the best algorithms and standards in order to produce high quality sea level products for climate applications. Particular attention will be paid on ESA missions.

3)To assess and collect information on the quality and error characteristics of the Sea Level ECV product through the involvement of independent climate research groups.

4)To provide a complete specification of the operational production system that should be developed during the phase 2 of the ESA CCI programme.

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Sea-level improvements

• The improvements planned to improve the sea-level calculation concern several categories :

-The Instrumental parameters

-The orbit calculation

- The wet troposphere correction

} Main source of errors for the MSL stability

- Atmospheric, Sea-state bias and Oceanic tidal corrections

- High latitudes areas

- Coastal areas

Altimetry

Levels 1 & 2

- the calibration of the altimetry missions together

- the merging of all the altimetry missions together

Altimetry

Levels 3 & 4

Sea-level improvements

• For each category, several algorithms will be compared in order to select the best one :

⇒ Most of the algorithms will developed in the frame of sea-level-CCI project (development is on-going)

⇒ Other contributions coming from external project (REAPER,SALP,…) will be also analyzed

• For instance, for the orbit calculation, we have planned :

⇒ to develop new ephemerid datasets with the last standards for all the missions (GFZ)

⇒ to use other ephemerid datasets provided by others orbit center productions as ESA (Reaper), CNES, GSFC, JPL.

In fine, only one algorithm will be selected (for each category)

Validation strategy

• The validation phase to compare all the algorithms together and to select the best one is a crucial step of the project : it is called "**the round-robin phase**"

A main principle of the validation phase is to use a common set of validation diagnostics for all the algorithms which will be developed in the project.

This strong principle allows us to compare the impact of different algorithm categories together with comparable statistics.

⇒**This will be also a rigorous approach to characterize the sea-level altimetry errors.**

Validation strategy

• The validation diagnostics are composed in distinct types which allow us to check altimetry data with complementary objectives:

Type	Objective
Global internal analyses	Ensure the internal consistency of new proposed algorithms compared to standard or reference and to measure the global system performances improvements.
Global multi-mission comparisons	Measure the sea-level consistency improvements between different altimetry missions using the new algorithms
Global altimetry and In-situ data comparison	use independent data to measure the impact of new algorithms on the sea-level calculation derived from altimetry missions.

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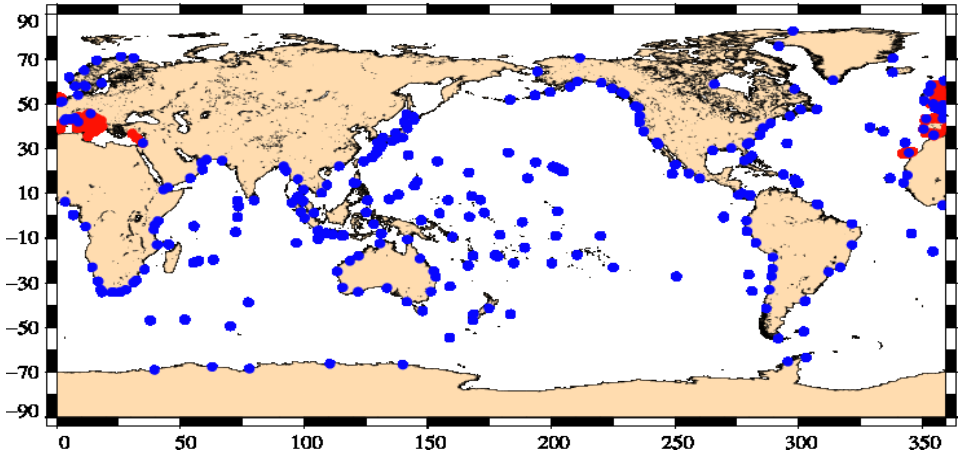
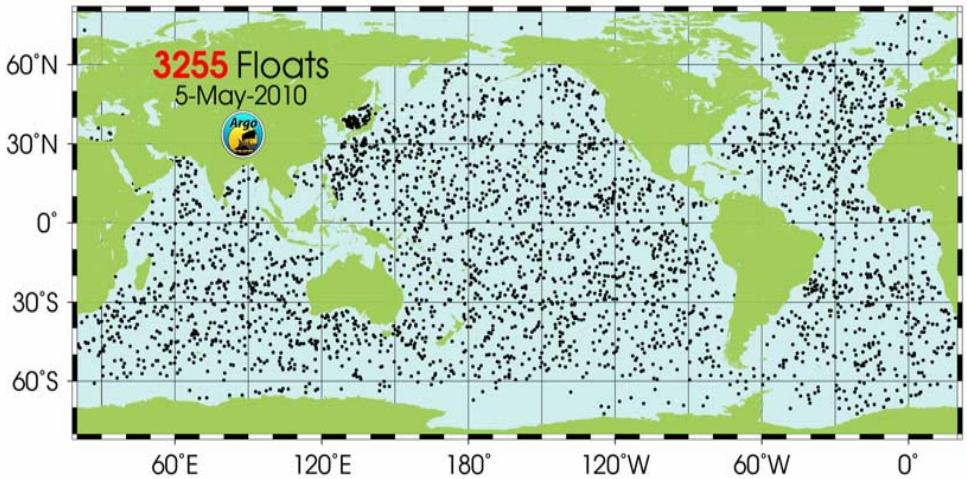
Altimetry and in-situ comparisons

• In-situ data used are:
- Tide gauges from global network (GLOSS/CLIVAR) and regional network (SONEL)
- Temperature and Salinity profiles from ARGO data

• Both data are complementary since tide gauges provide a very good temporal sampling (hourly) but a poor spatial sampling with data only close to the coasts, whereas ARGO data are very well spread out over the open ocean but with only a 10-day sampling.



GLOSS/CLIVAR (blue dots) and SONEL networks (red dots): about 400 tide gauges



Global comparison from mid 2004 with more than 3000 profiles and 80% of ocean surface covered

Altimetry and in-situ comparisons

- The methodology to compare tide gauge and altimetry SSH is composed of the following steps :

⇒ Calculation of the altimeter and tide gauge SSH applying DAC and tidal corrections, MSS

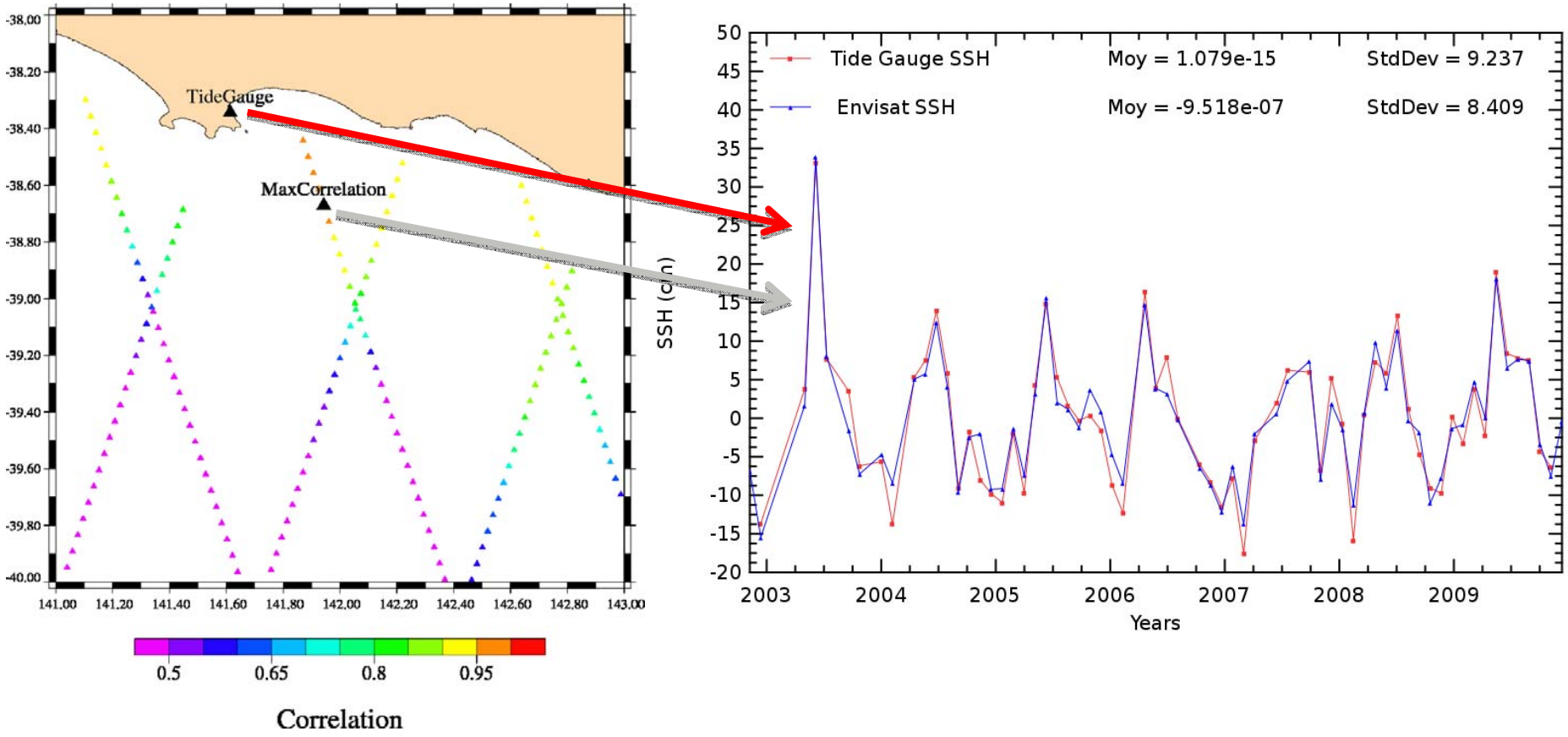
⇒ Colocation of altimeter and in-situ data selecting the the best correlated altimeter time data series with tide gauge one (within a maximal distance)

⇒ Calculation of SSH differences at each tide gauges after removing colocated time data series which are not well correlated enough (due geophysical processes, jump in tide gauges) and too short tide gauge time data series

- More information are available on AVISO website, see Annual reports :

http://www.aviso.oceanobs.com/en/calval/index.html

Altimetry and in-situ comparisons



Altimetry and in-situ comparisons

- The Methodology to compare T/S profiles and altimetry SSH is different since T/S in-situ profiles only measure the steric part of the water column whereas altimeters measure the total height (mass and steric) :

  ⇒ need to use of regression coefficients to extrapolate the steric content of T/S profiles to the total water column

  ⇒ Spatial / temporal interpolation between in-situ profiles and 10-days mean gridded altimeter data (to provide sufficient spatial density of data)

  ⇒ Global statistics and coherence analyses between two types of data

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Altimetry and in-situ comparisons

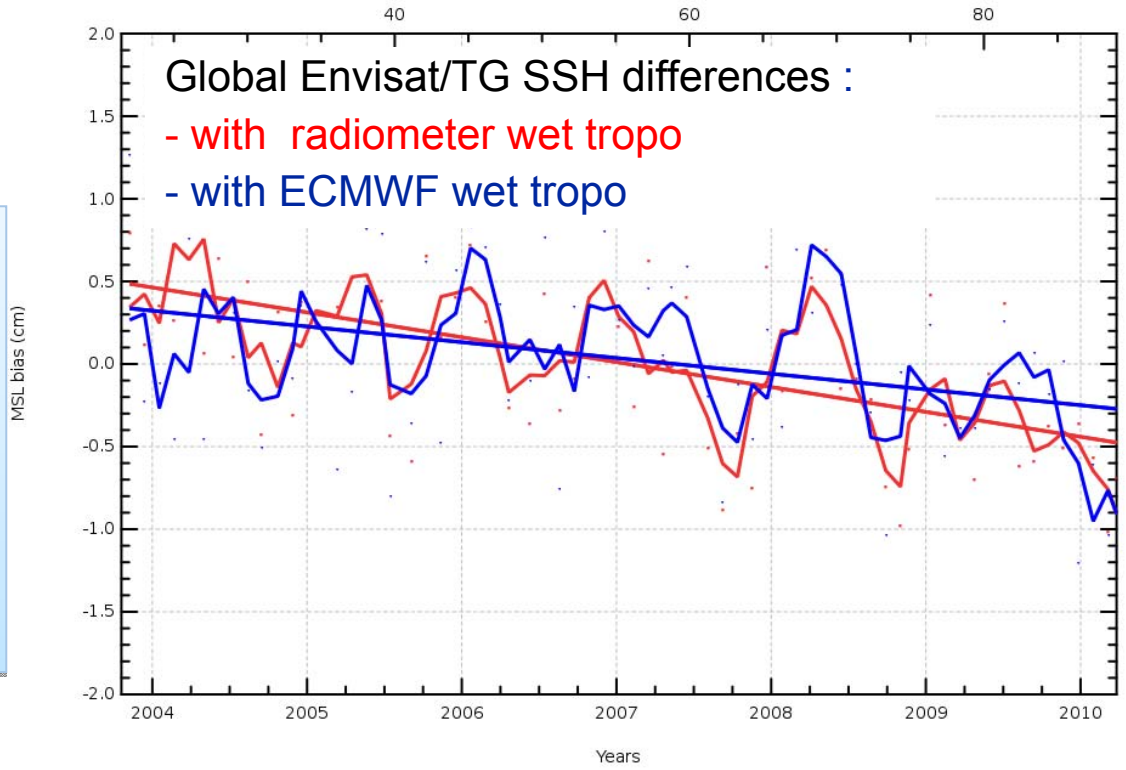
- Thanks to these in-situ and altimetry SSH comparisons, the impact of using new altimetry standards on the SSH calculation can be estimated

⇒ Impact on the global MSL drift

- Envisat/TG MSL drifts have been calculated using successively :

⇒ Radiometer wet tropo = -1.5 mm/yr

⇒ ECMWF wet tropo = -1.0 mm/yr



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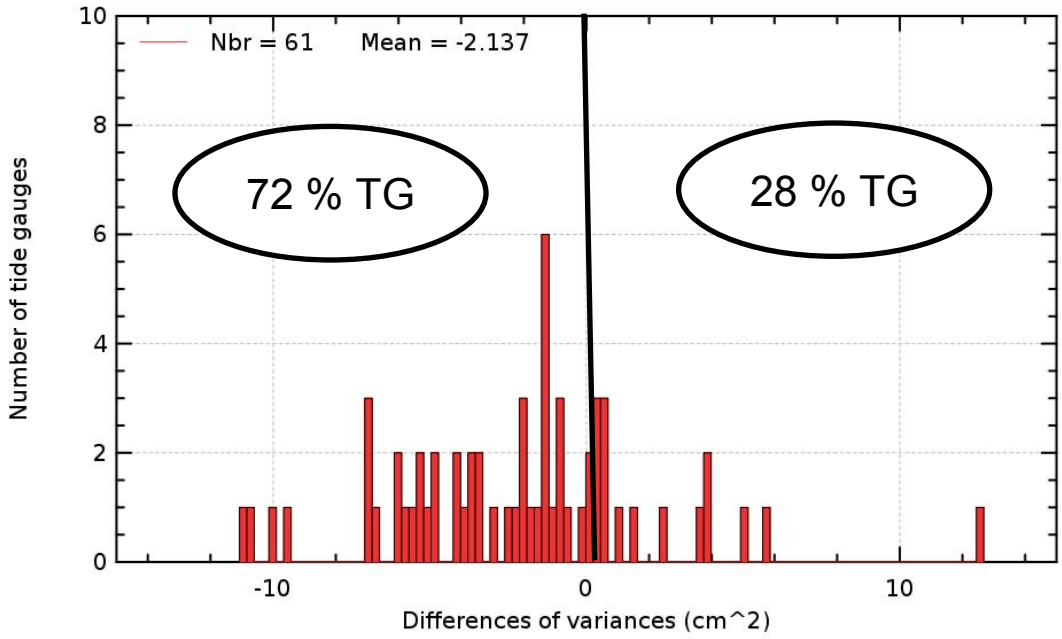
⇒ Impact on the SSH consistency

- Envisat and TG have analysed using succesively GDR-B and GDR-C release of Envisat products

⇒ A significant reduction of variance is displayed using Envisat GDR-C products (-2.1 cm²) showing a better consistency between TG and altimetry

⇒ 72 % of TG with SSH variance differences reduced

Histogram of the difference of variances :
Var(ENnew-TG) – Var(ENold-TG)

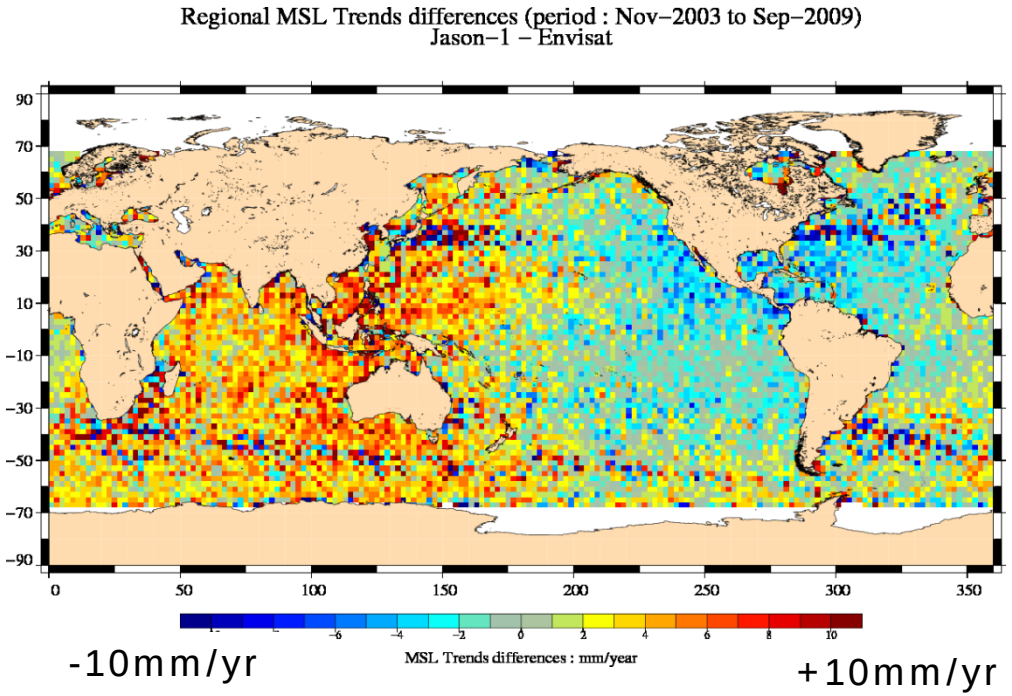


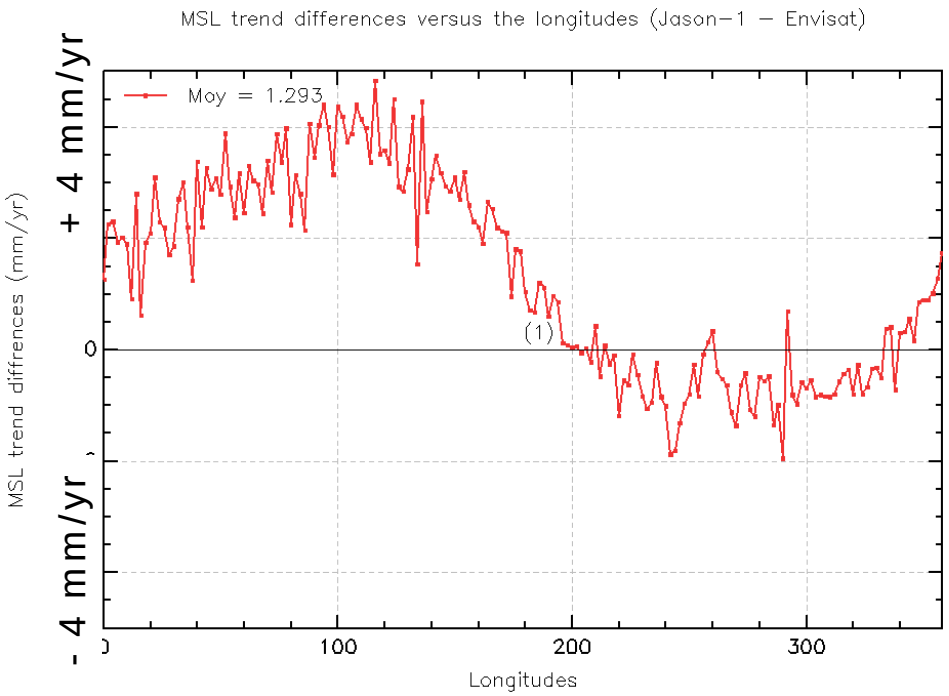
Altimetry and in-situ comparisons

- Altimetry and in-situ comparisons can also be useful to demonstrate which mission is right when SSH disrepancies are detected between two or several altimetry misions.

- Regional MSL trend differences have been detected between Jason-1 and Envisat :

⇒ a MSL drift ranging from -2 to + 4 mm/yr versus the longitudes





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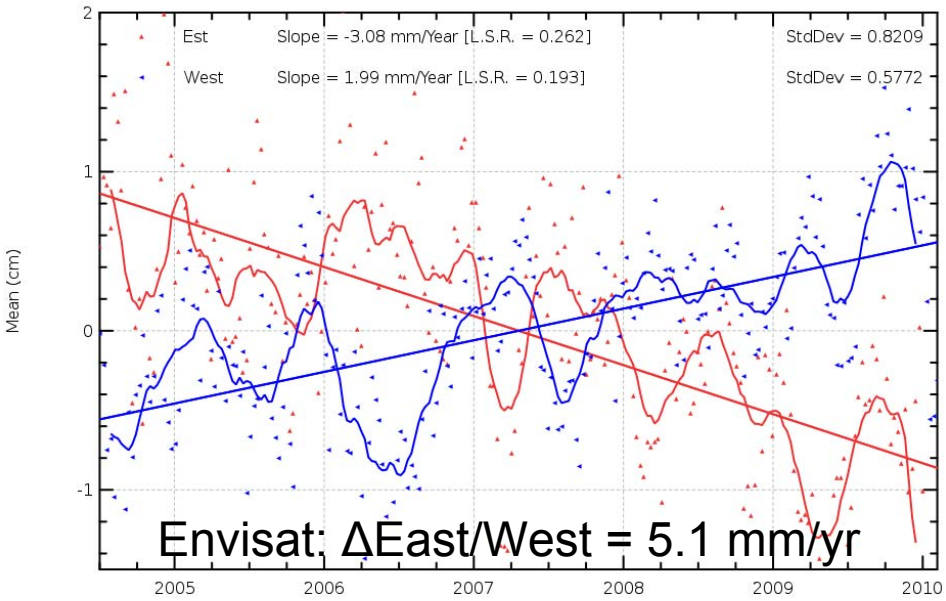
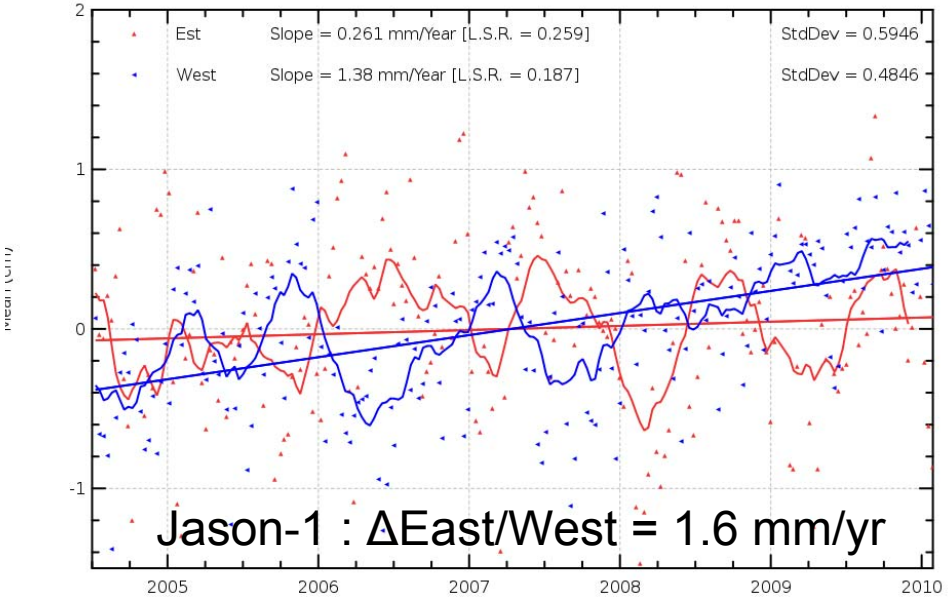
- Calculating Envisat and Jason-1 SSH drift with T/S profiles and separating East (0°/180°) and West (180°/360°) part, we observe that the East/West drift is more homogenous comparing Jason-1 and T/S profile than comparing Envisat and T/S profiles
- In this case, we demonstrated that the differences observed is mainly an error on the Envisat MSL





Conclusion

• All the information concerning the Sea-level-CCI project are available on the website : http://www.esa-sealevel-cci.org/

⇒Newsletters are periodically performed

• The sea-level-CCI altimetry database updated with all the new algorithms is available for all the participants (internal and external to the project)

⇒ A first version is already available on the ftp site : ftp://ftp.esa-sealevel-cci.org/

• At the moment :

⇒The development of new algorithms is on-going

⇒ The validation phase is also started

• The round-robin data package containing all the validation diagnostics will be also available on the ftp site : ftp://ftp.esa-sealevel-cci.org/

⇒You are invited to consult them and share your own analyses or studies

⇒ Some of them are already on-line

Do not hesitate to contact us !