New insight in resolving long term and inter-annual signal for climate studies

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Introduction

- Altimetric system have benefitted from the last improvements of POD standards
- In return, the study of altimetry performance provides a complementary assessment to intrinsic orbital diagnosis

- This work focuses on the complementary studies performed to understand the links between **long term Mean Sea Level trends** at regional scales and the different choices made to compute in the Orbit determination
  - Since 2007, the studies of performance analysis in altimetry demonstrated the impact of **Gravity field** on the consistency between missions.
  - Later, **multimission analysis** and **in situ comparisons** have also demonstrated the better reliability of more recent Gravity fields, now included in the official products'POD…

Introduction

Outlines:

1- Long term effects of orbits based on EIGEN6S2 gravity field

Those studies are carried on concerning the gravity fields, thanks to the recent integration of the latest gravity field (**GFZ-GRGS EIGEN6S2**) in POD test solutions.

2- Towards a climate dedicated orbit for Jason-1

Another impact was analysed concerning the **seemless transition on a regional scale** between the time series of two **consecutive missions** (here J1,J2) for climate studies.

Long term and inter-annual signal:
Impact of the gravity field

In GDR-D POE :EIGEN-GRGS_RL02bis_MEAN-FIELD:
•Linear drift unique over the whole GRACE period

New GRGS-GFZ field EIGEN 6S2:
• 2 more years of GRACE data (< 2012) + GOCE
• interannual variability added to the gravity field model, linear per piece over 1 year interval
• Extrapolation after 2012 performed with the last biais (of 2012) and a null drift

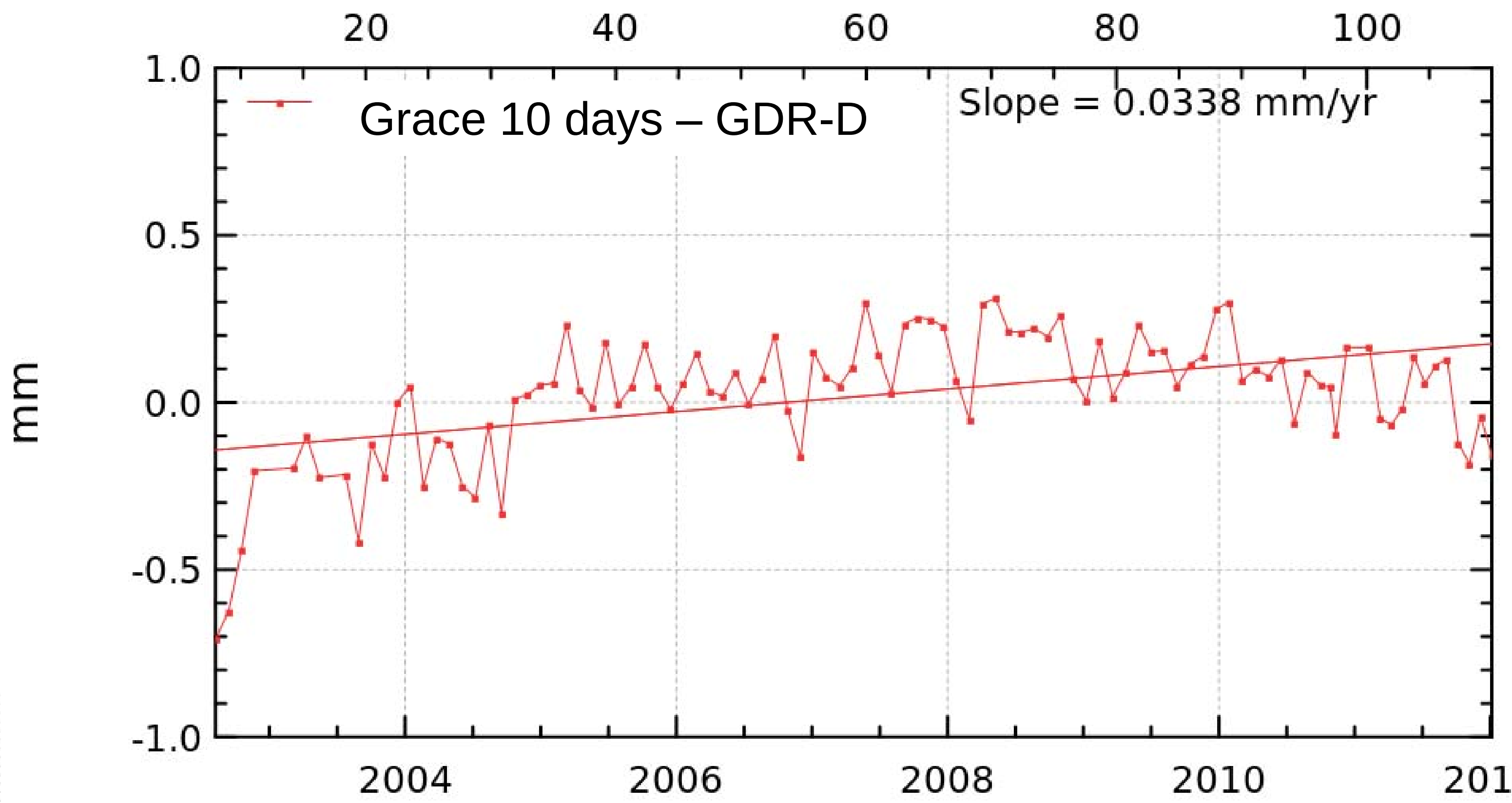
More info on http//grgs.obs-mip.fr/grace/variable-models-grace-lageos/mean_fields

We analyse the impact on long term Mean Sea Level trends

Long term and inter-annual signal:
Impact of the gravity field

Last OSTST (example Envisat):
Residual interannual error (beginning and end of the series reaching locally 3mm)

GDR-D:
Max
amplitude
of 0.5mm



Long term and inter-annual signal:
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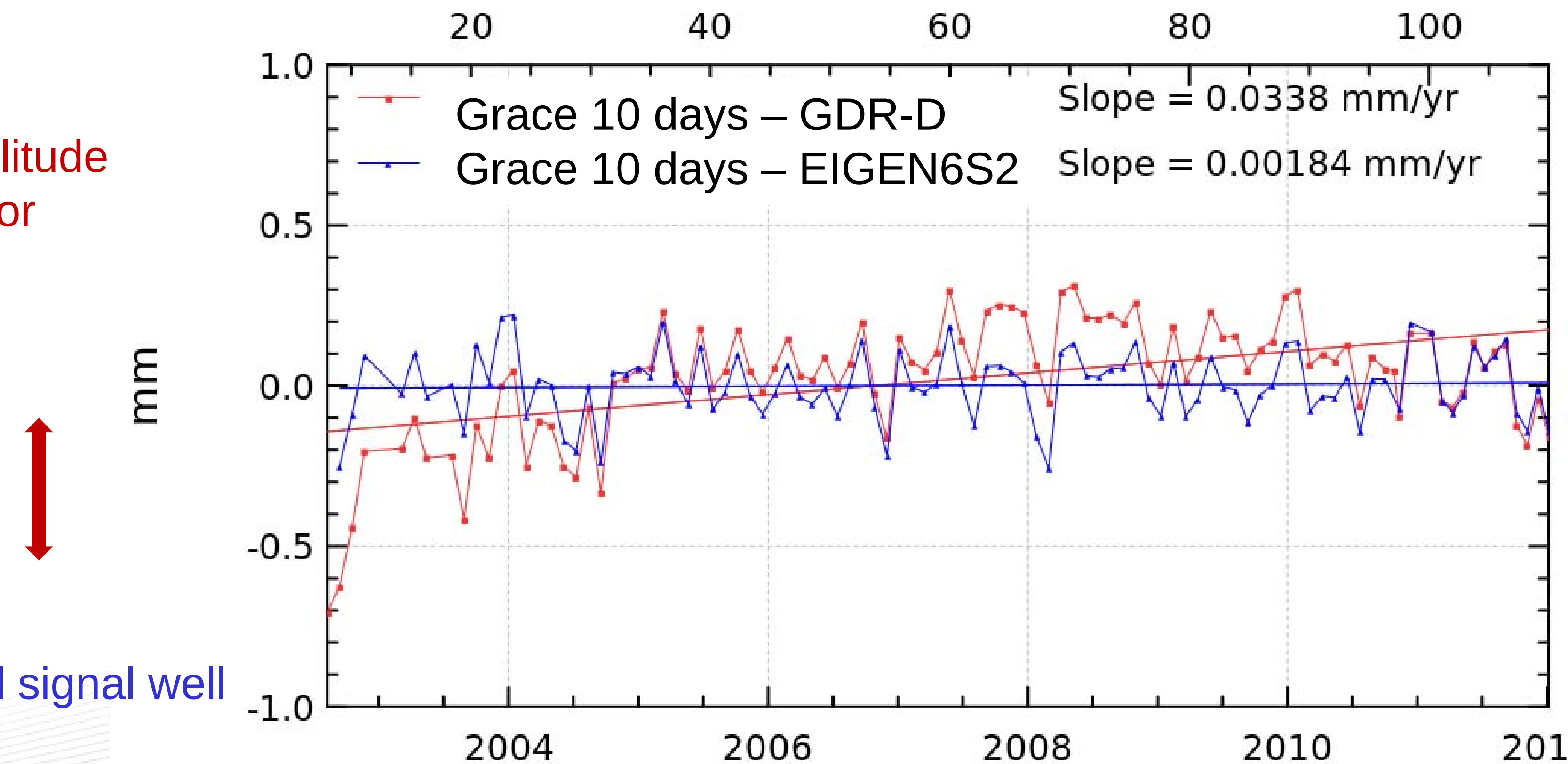


Interannual signal well restituted

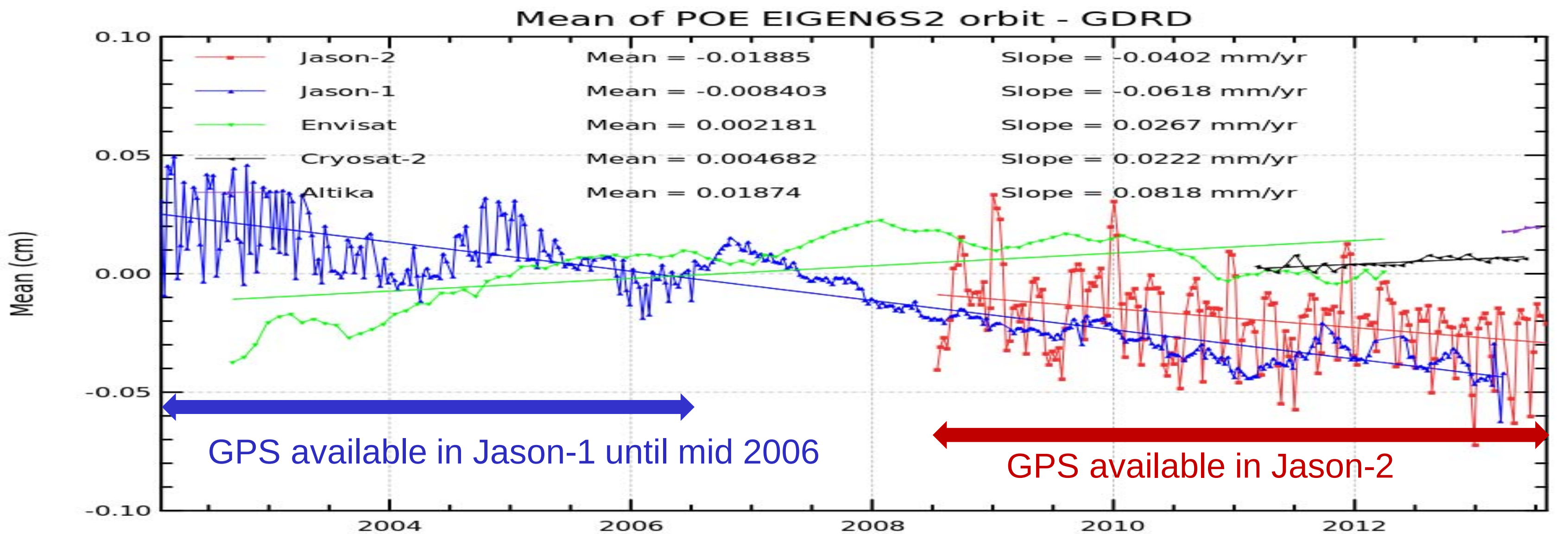
With new gravity field: No impact on the long term drift but a weak impact on the interannual variability ➔ expected and closer to Grace 10 days reference!

Long term and inter-annual signal:

Impact of the gravity field

Impact on other missions:
Negligible on global MSL + Small on interannual signal

Effect of a particular processing applied on orbit solutions including GPS (Jason-1 before mid 2006 + Jason-2): orbit difference noisier



Extract from IDS site: The POE orbit is obtained using all the tracking techniques available for a given satellite:
- Doris only for Spot satellites,
- Doris+ SLR for Topex, Envisat, Cryosat-2, Hy-2a,
- Doris+SLR+ GPS for Jason-1 and Jason-2

Long term regional signal:

Impact of the gravity field

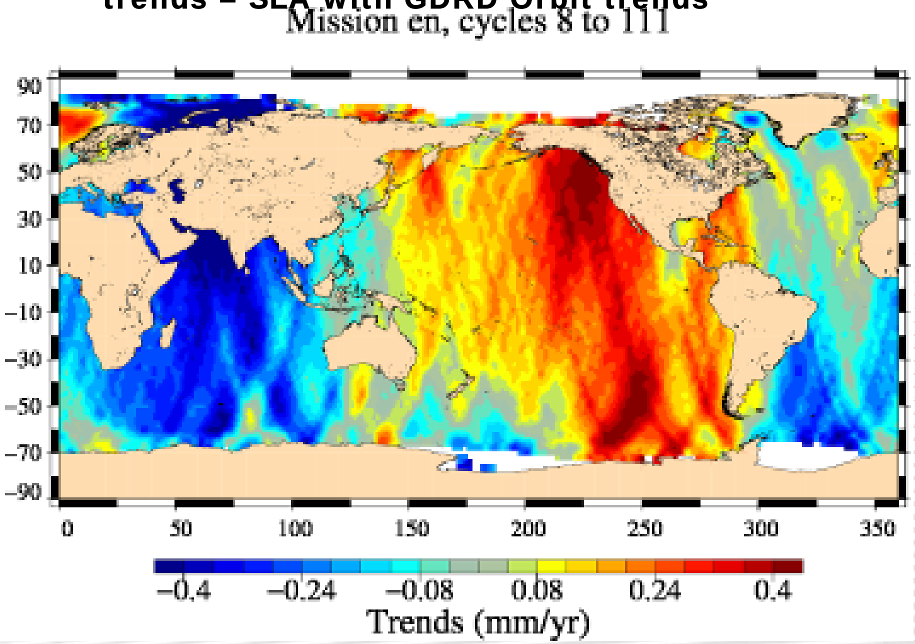
At regional scale:

Error remaining between **GDR-D POE** and **Grace 10 days** orbit (which is considered as reference)

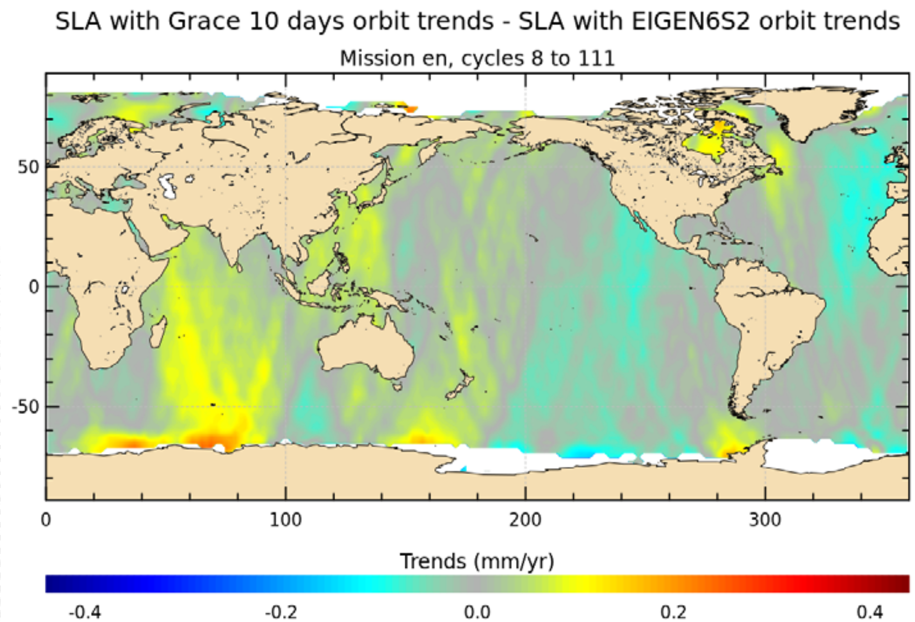
➔ With the new EIGE6S2 POE better agreement than GDRD orbit for long term evolution of regional mean sea level (ex of Envisat)

Extract of OSTST 2012

SLA with ORB_POE_GRACE_10DAYS trends – SLA with GDRD Orbit trends



SLA with POE GRACE 10days trends – SLA with EIGEN6S2 Orbit trends

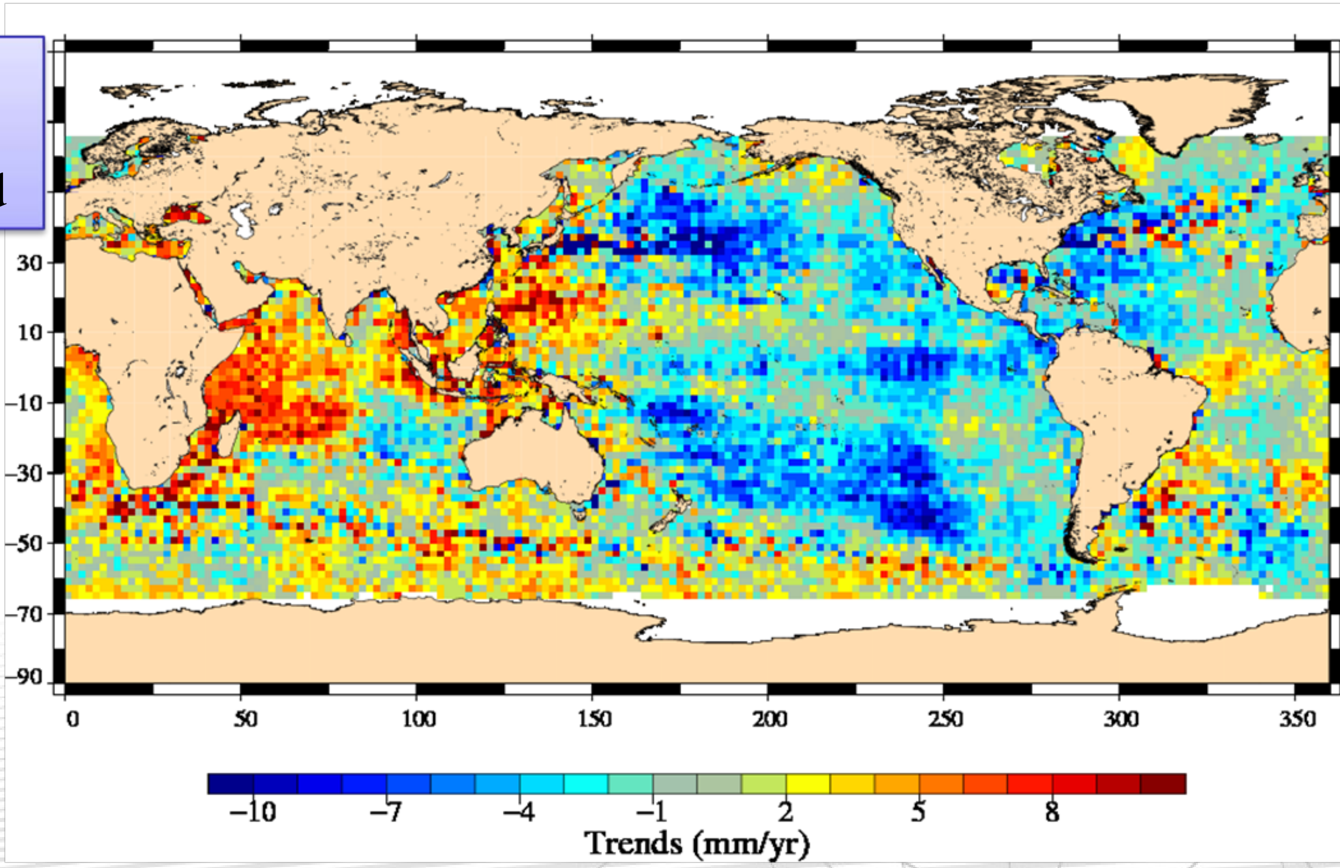


Envisat

Long term regional signal:
Impact of the gravity field

Since a few years, we evidenced the effect of gravity field on the regional trends via comparisons to in situ data and to multimission comparison (notably EN –J1 trend differences)

J1: POE-C
EN: POE-ABC
inhomogeneous gravity field



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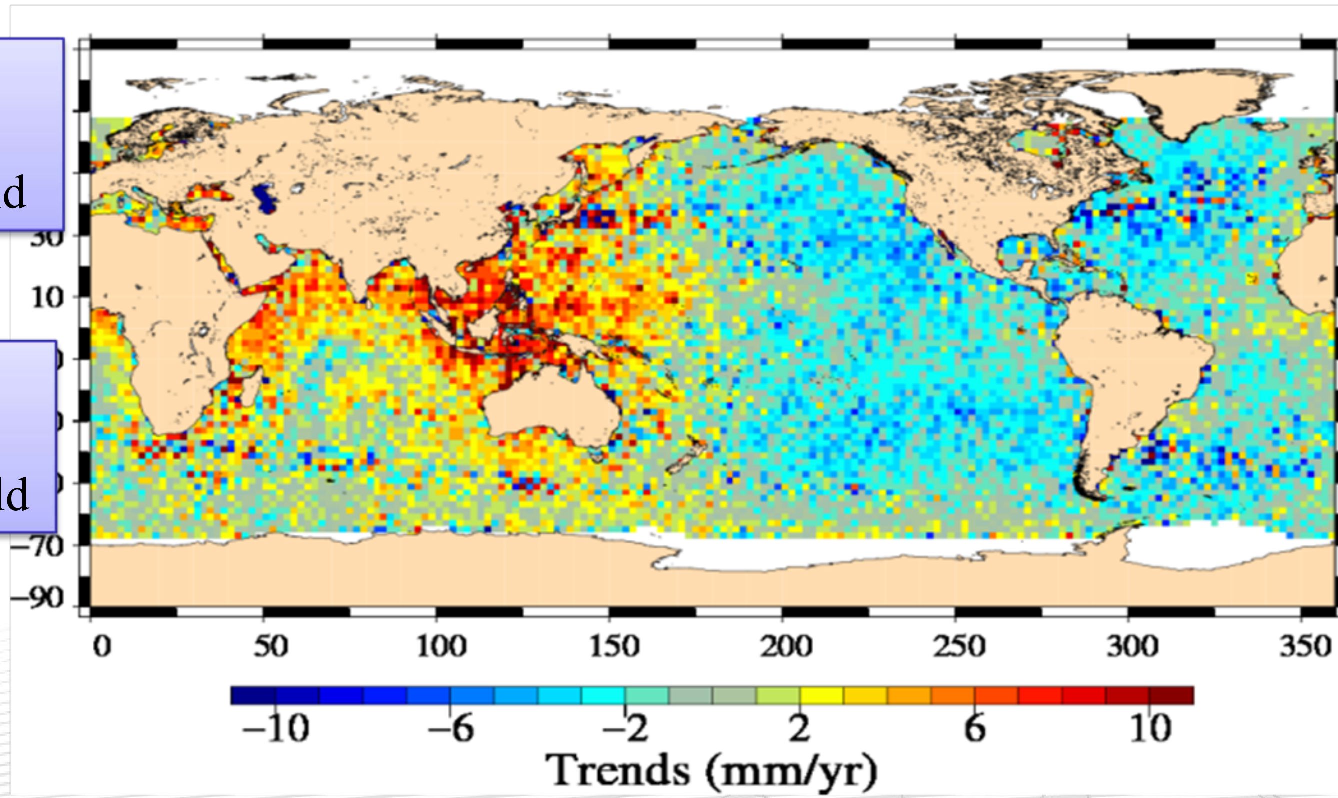
EIGEN-GL04S gravity field



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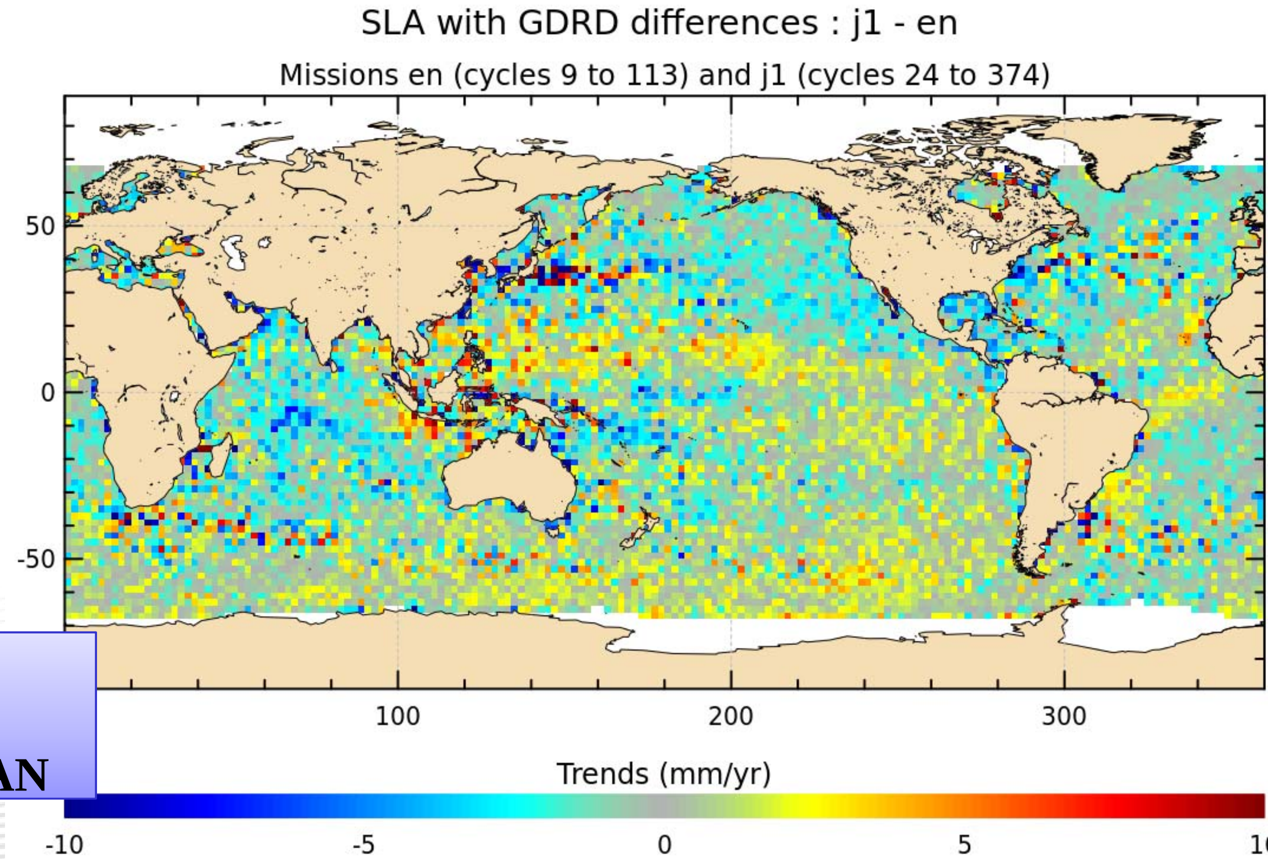
J1: POE-C
EN: POE-C
EIGEN-GL04S gravity field

J1: POE-D
EN: POE-D
EIGEN-GRGS_RL02bis_MEAN



Long term regional signal:

Impact of the gravity field

Since a few years, we evidenced the effect of gravity field on the regional trends via comparisons to in situ data and to multimission comparison (notably EN –J1 trend differences). The improvements getting harder to evidence.

J1: POE-C
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inhomogeneous gravity field

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J1: POE-D
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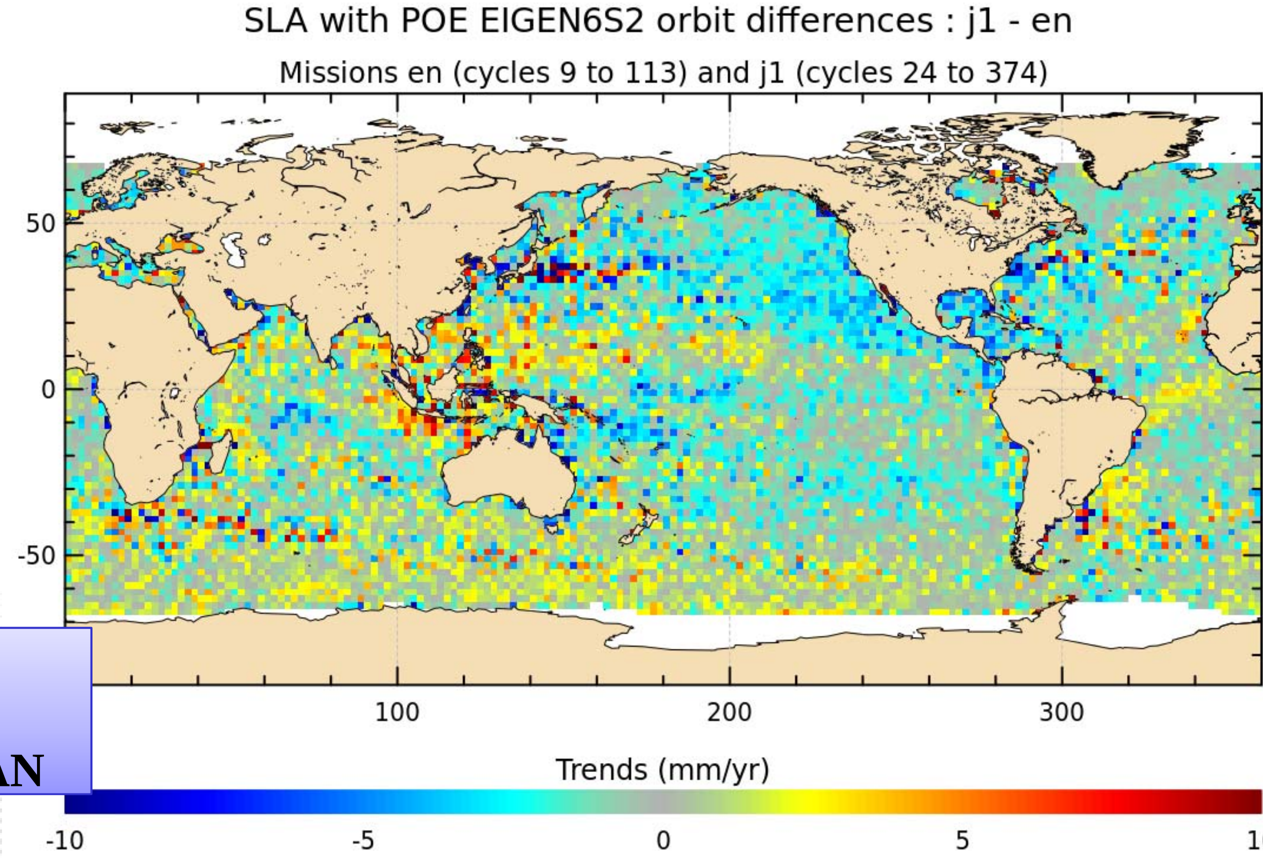
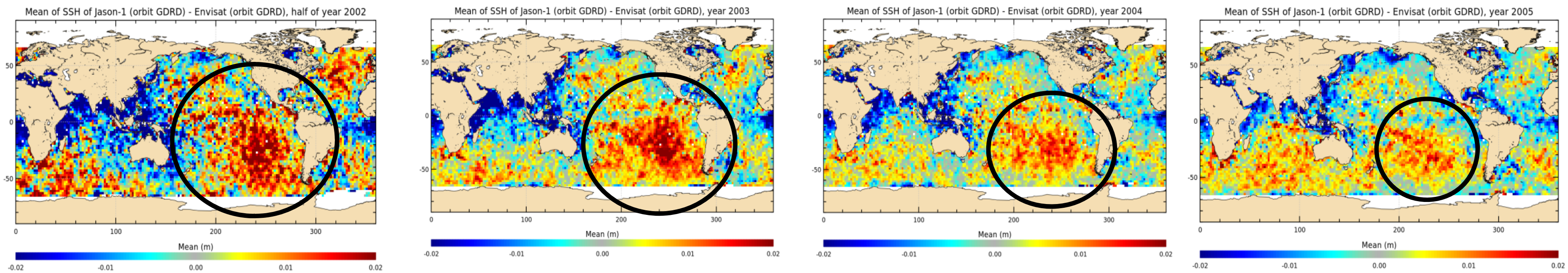
EIGEN6S2



Inter annual regional signal:
Impact of the gravity field

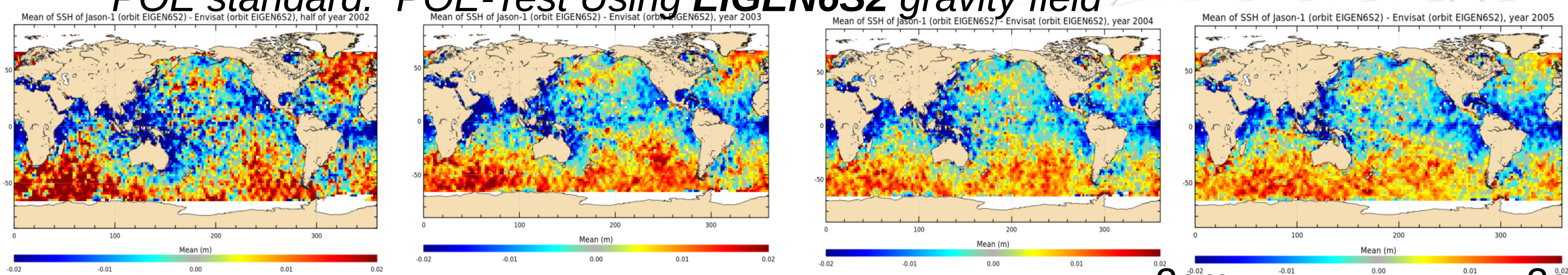
Interannual signal East/West patches remaining on EN-J1 mean difference per year at crossovers efficiently removed!

*POE standard: POE-D Using **EIGEN-GRGS_RL02bis_MEAN** gravity field*



2002 2003 2004 2005

*POE standard: POE-Test Using **EIGEN6S2** gravity field*



-2cm 2cm

Remaining signals now dominating between those missions are most probably due to a mix of other sources (wet tropospheric correction, SSB solutions...)

Plan

Plan of the talk:

1- Long term effects of orbits based on EIGEN6S2 gravity field

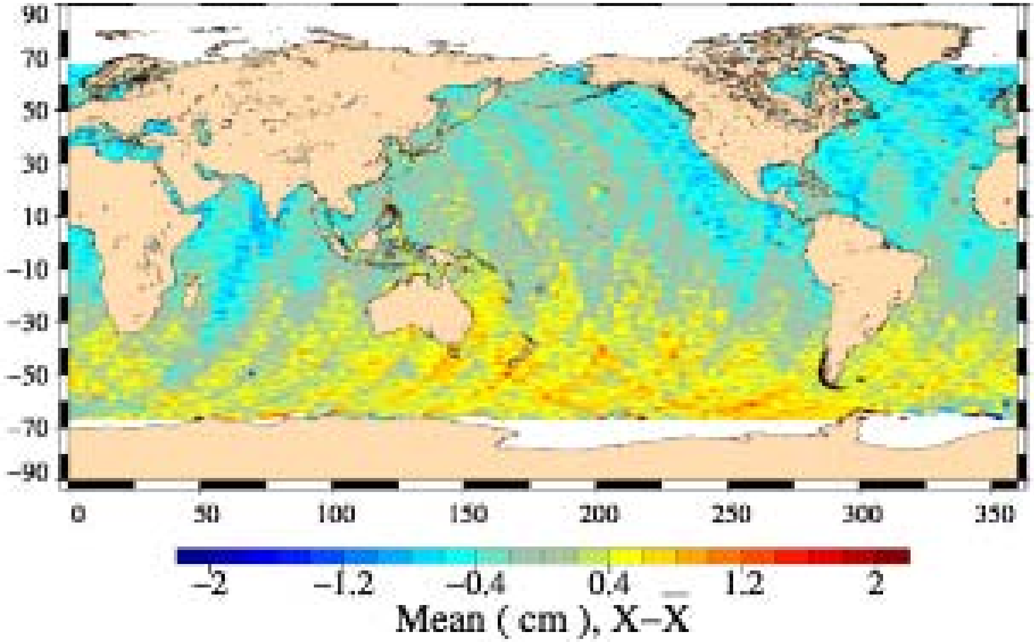
2- Towards a climate dedicated orbit for Jason-1

Towards a climate dedicated orbit for Jason-1

POE-D: weak North/South differences remain between Jason-1 and 2
After investigation and fruitful exchanges with POD teams, we evidenced that this was not due the lack of GPS on J1 (Doris Laser solutions from mid-2006) but rather to a different approach for the JA1 and JA2 of taking into account DORIS stations in the South Atlantic Anomaly (SAA).

J1-J2 centered mean SSH difference during the formation flight phase (july2008-january2009)

J1 – J2 along track residuals Using standard GDR-D POE



Towards a climate dedicated orbit for Jason-1

- Indeed, Jason-1 is sensitive to the South Atlantic Anomaly.
- A solution of the problem consists in down-weighting of the DORIS station of the SAA zone ➔ reduces efficiently the variance at crossovers.
- Today, we observe a drawback of this evolution with an impact on the long trend estimation at regional scales when connecting two consecutive missions.

➔ North/South difference between Jason-1 and Jason-2 has to be taken into account for regional trend estimation of multi-mission dataset.

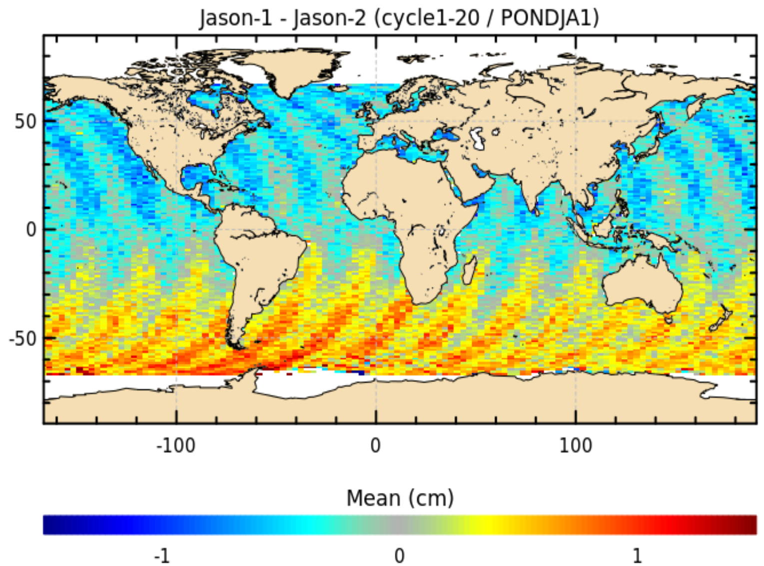
➔ Can be corrected empirically afterwards but datasets without this regional differences are preferable for climate studies

Towards a climate dedicated orbit for Jason-1

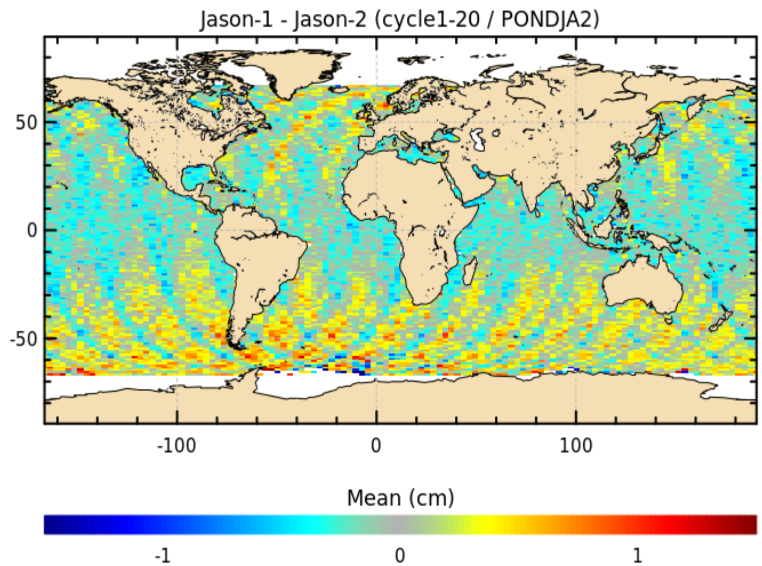
Our tests were performed on pure Doris solutions to study only the impact of the weighting strategy of SAA stations for Jason-1

J1-J2 centered mean SSH difference during the formation flight phase (july2008-january2009)

J2 POE = DORIS only “GDR-D like”
J1 POE = DORIS only “GDR-D like” including downweighting of South Atlantic Anomaly



J2 POE = DORIS only “GDR-D like”
J1 POE = DORIS only “GDR-D like” **without** downweighting of South Atlantic Anomaly (as for J2)

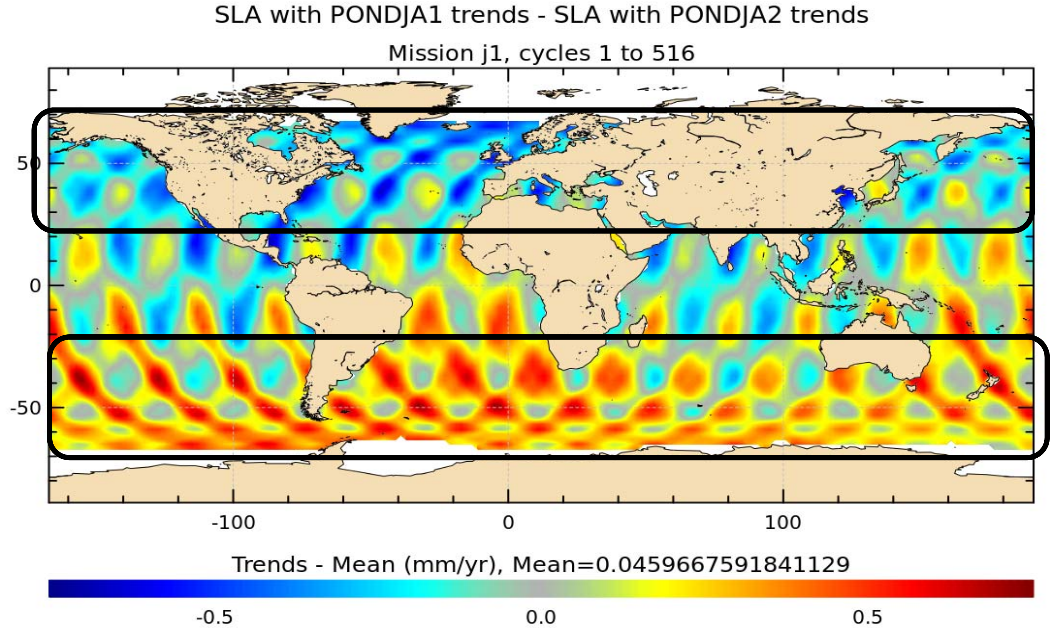


The North/South effect disappears!: it is explained by the particular down-weighting applied on Jason-1

Towards a climate dedicated orbit for Jason-1

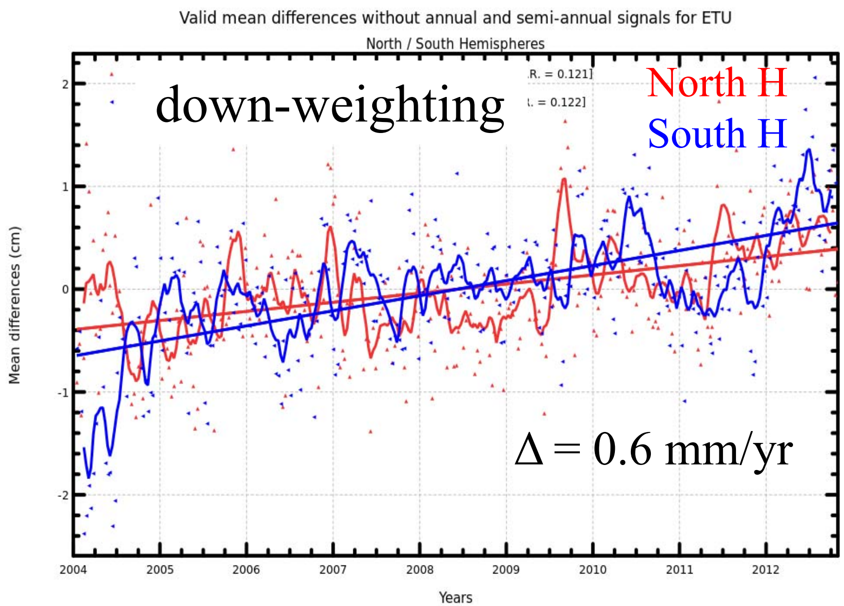
- North/south bias between solutions with or without down-weighting of SAA Doris stations varies locally (+/- 1 mm/yr) in time (over the whole Jason-1 time series)

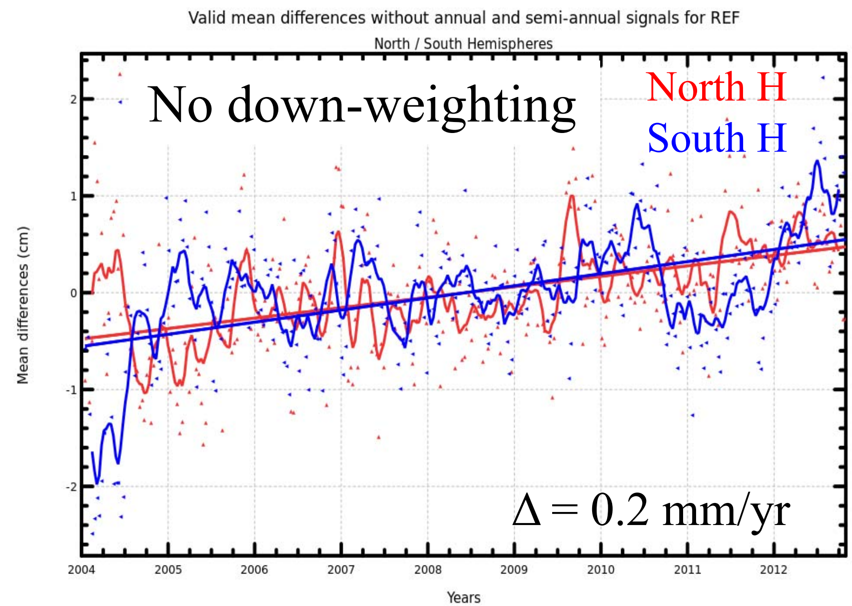
Effect of the weighting of SAA stations varying in time



To determine if the trend is more relevant with one or this other solution ➔ comparison of trends (above 20°N and below 20°S) with an external data source: Argo Temperature Salinity profiles (see Prandi et al.'s talk, Calval session).

Towards a climate dedicated orbit for Jason-1





This comparison enabled to show that :

On Jason1, down-weighting of SAA stations leads to **less homogeneous** values for North and South hemisphere trends than without down-weighting compared to Argo data

Towards a climate dedicated orbit for Jason-1

This study showed that removing the down-weighting of DORIS station in the South Atlantic Anomaly for Jason-1 reduces efficiently the small North/South bias between Jason-1 and Jason-2, with a much finer precision than a posteriori bias map (which does not vary in time):

This orbit solution

- improves consistency between Jason-1 and Jason-2,
- improves Jason-1 consistency with Argo data

For long term studies, this type of orbit would be of interest for Jason-1.

The remaining work to consolidate this proposal would consist in analysing the impact of removing the SAA down-weighting on a multitechnique solution (DORIS,Laser and GPS when available) in terms of long term stability and mesoscale consistency.

Conclusions

Summary:

- The EIGEN6S2 gravity field reduces the errors previously identified on the interannual signal of Sea Level at regional scale compared to the one available in the GDR-D standards
- Very weak discrepancies between J1/J2 for cnes POE standards during formation flight phase are explained and could be solved for climate scale studies.
- **Lessons learned:**
- Cross comparisons studies highlight weaker and weaker discrepancies between sister or independent missions.
- The recent improvements made in the orbit modelisation enable to stretch the limits of orbit estimation and reduce these errors (see Couhert talk)

Thank you for your attention!