Assessment of Orbit Quality through the Sea Surface Height calculation: Modelling the Geocenter

A. Ollivier[1], L. Zawadzki[1], A. Couhert[2] , M. Lievin[1], N. Taburet[1], M. Ablain[1]

[1]CLS, [2]CNES

Annabelle.Ollivier@cls.fr

CLS COLLECTE LOCALISATION SATELLITES

cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

SALP Service Altimetrie & Localisation Precise

OST/ST 2016

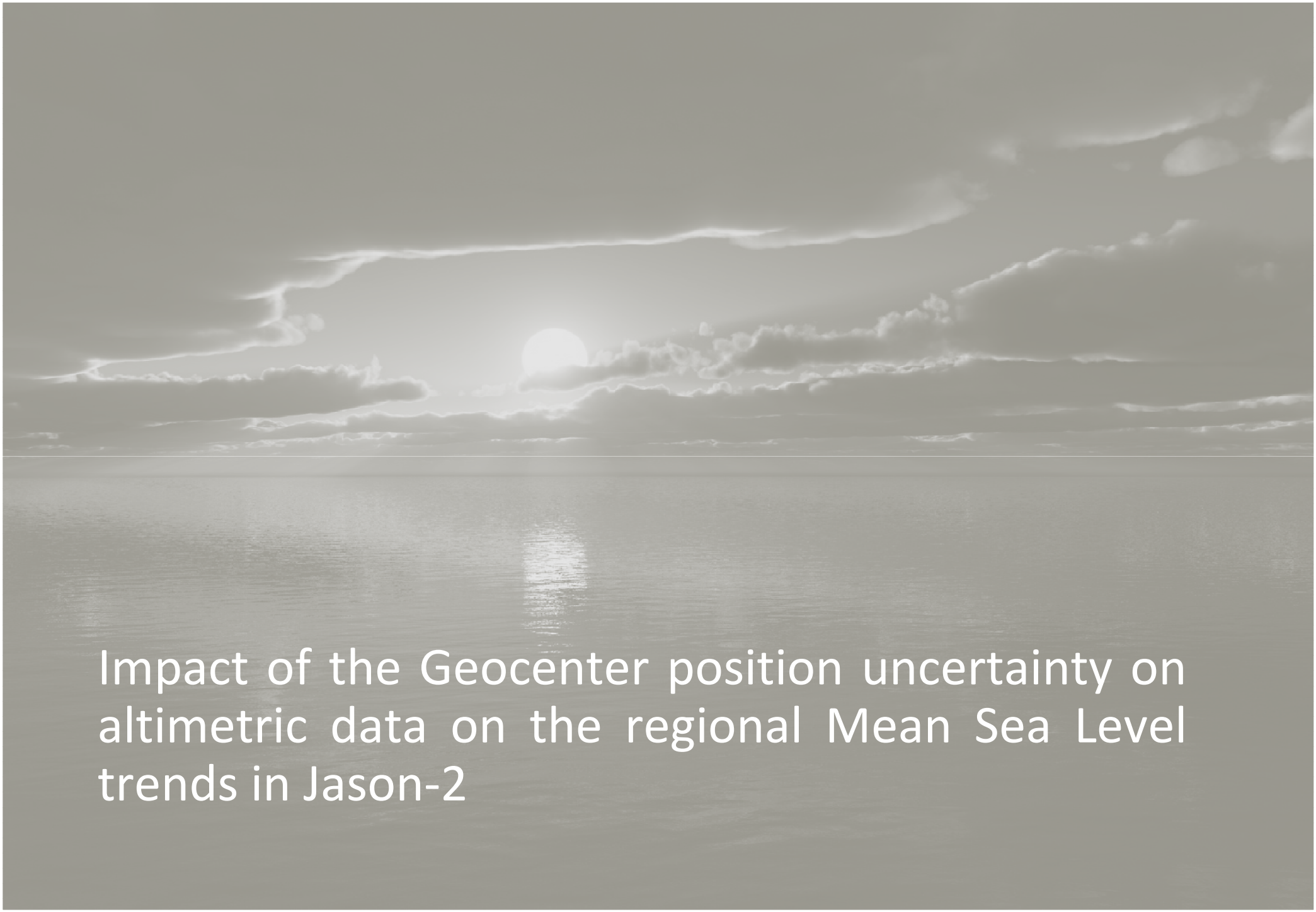
La Rochelle, France

Context

- New **GDR-E** standards are reaching a very good quality (cf. OSTST 2015)

- Thanks to GRACE-based models, Gravity field errors are now much reduced. Smaller and smaller errors –considered as negligible before- are now observable.

- This highlighted the fact that **changing the geocenter position can induce millimetric variations on the orbits (order of magnitude of the precision required for climate studies)**



Impact of the Geocenter position uncertainty on altimetric data on the regional Mean Sea Level trends in Jason-2

How can we isolate the impact of Geocenter position alone?

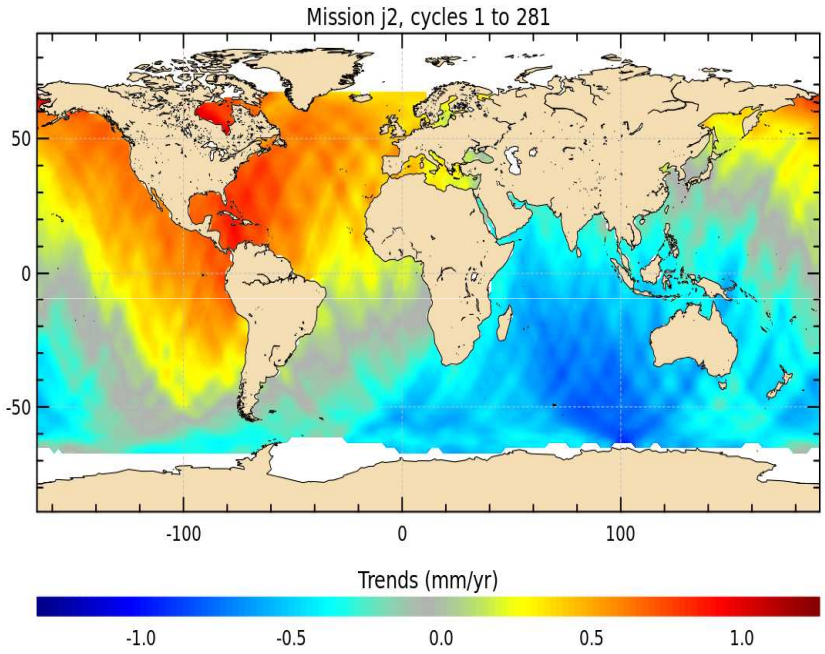
- GPS constellation reference network is aligned to ITRF origin → Estimating the geocenter position from GPS constellation is not possible in the current solution
- Hence, this study is performed on **pure DORIS orbit solutions**.
- Besides, a **dynamic model** is used in order to focus on the Z impact (unlike reduced dynamic which effect was shown to be mixed in X, Y and Z directions, see A. Couhert's talk)

	Geocenter model	Technics	Mission
POE-E standard	Ries model = annual motion (no drift) of the LASER reference geocenter	DORIS + GPS Reduced dynamics model	Jason-2
DORIS Dyn Ries	Ries model = annual motion (no drift) of the LASER reference geocenter	DORIS Dynamic model	Jason-2

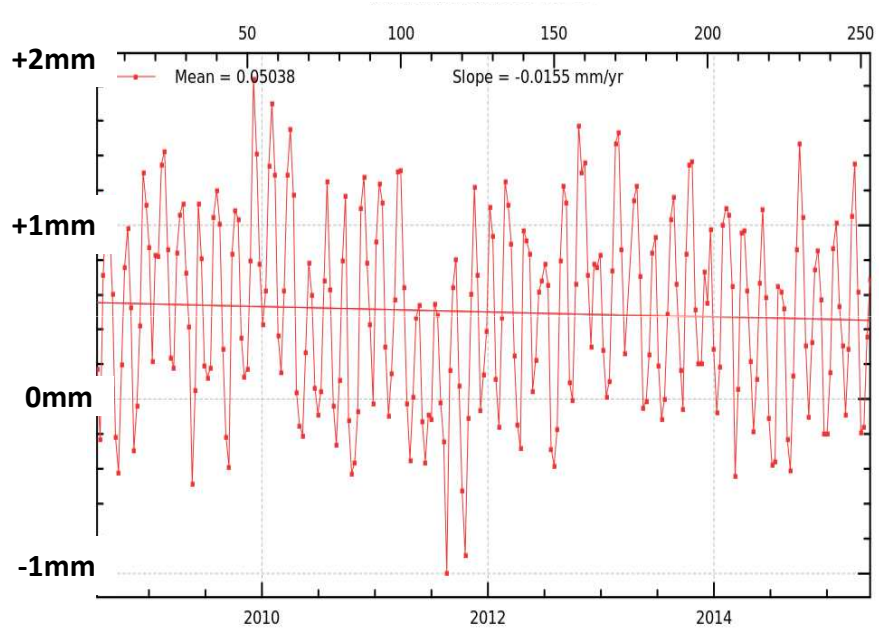
Effect of the orbit solution on Mean Sea Level

Dynamic DORIS Ries - POE-E standard (Reduced dynamic, DORIS+GPS)

Sea Level Anomaly trend differences



Mean Sea Level Anomaly differences

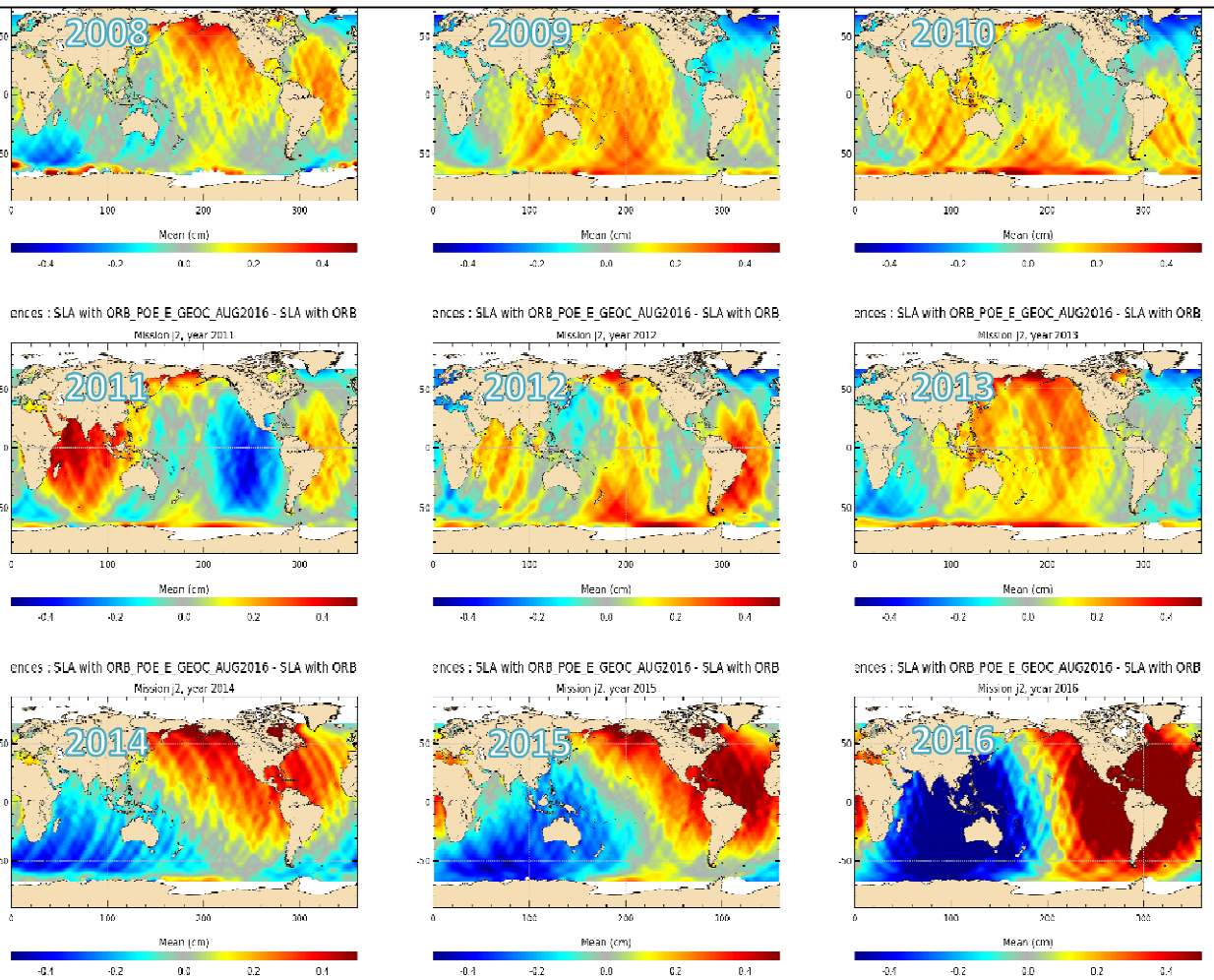


- No global trend difference but 1mm.yr^{-1} impact on regional trend
- Large scale effects very variable in time

Effect of the orbit solution on Mean Sea Level

Dynamic DORIS Ries - POE-E standard (Reduced dynamic, DORIS+GPS)

Mean Sea Level Anomaly differences: non linear complex signal in time and space



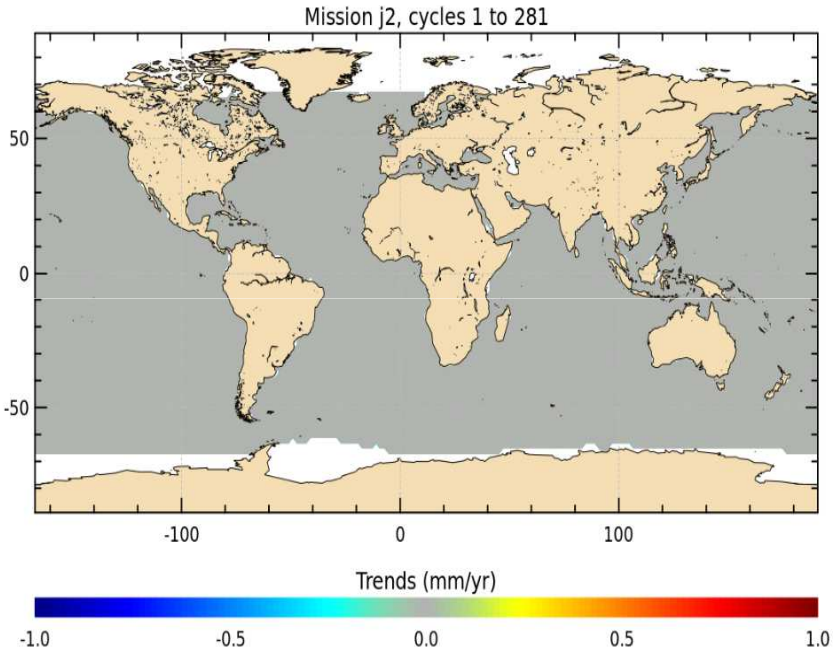
How can we isolate the impact of Geocenter position ?

	Geocenter model	Technics	Mission
DORIS Dyn Ries	Ries model = annual motion (no drift) of the LASER reference geocenter (~GDR-E)	DORIS Dynamic model	Jason-2
DORIS Dyn NoGeoc	No geocenter model (~GDR-D)	DORIS Dynamic model	Jason-2
DORIS Dyn FF	Fiducial free: DORIS geocenter motion estimated with free network (w.r.t ITRF2008/DPOD2008)	DORIS Dynamic model	Jason-2

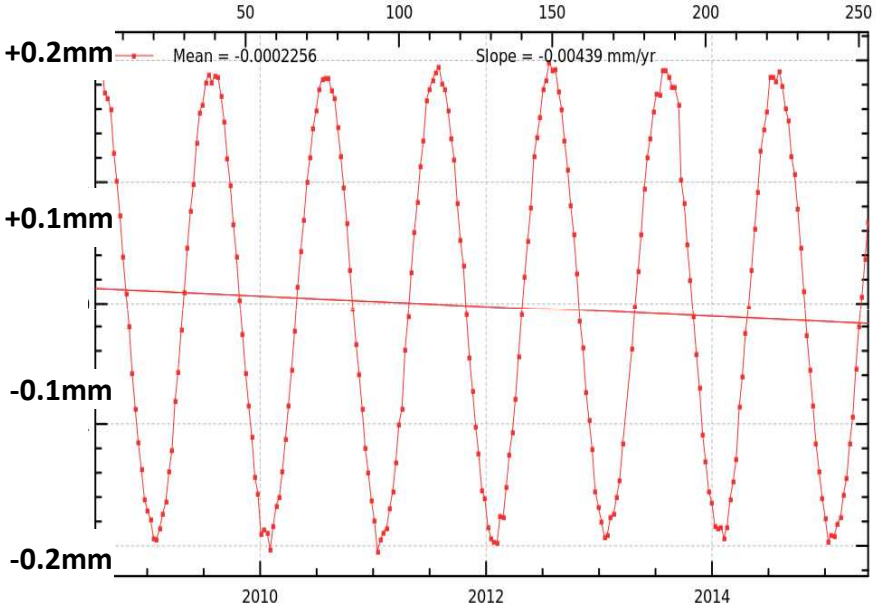
Effect of the orbit solution on Mean Sea Level

Dynamic DORIS Ries - Dynamic DORIS No Geocenter

Sea Level Anomaly trend differences



Mean Sea Level Anomaly differences



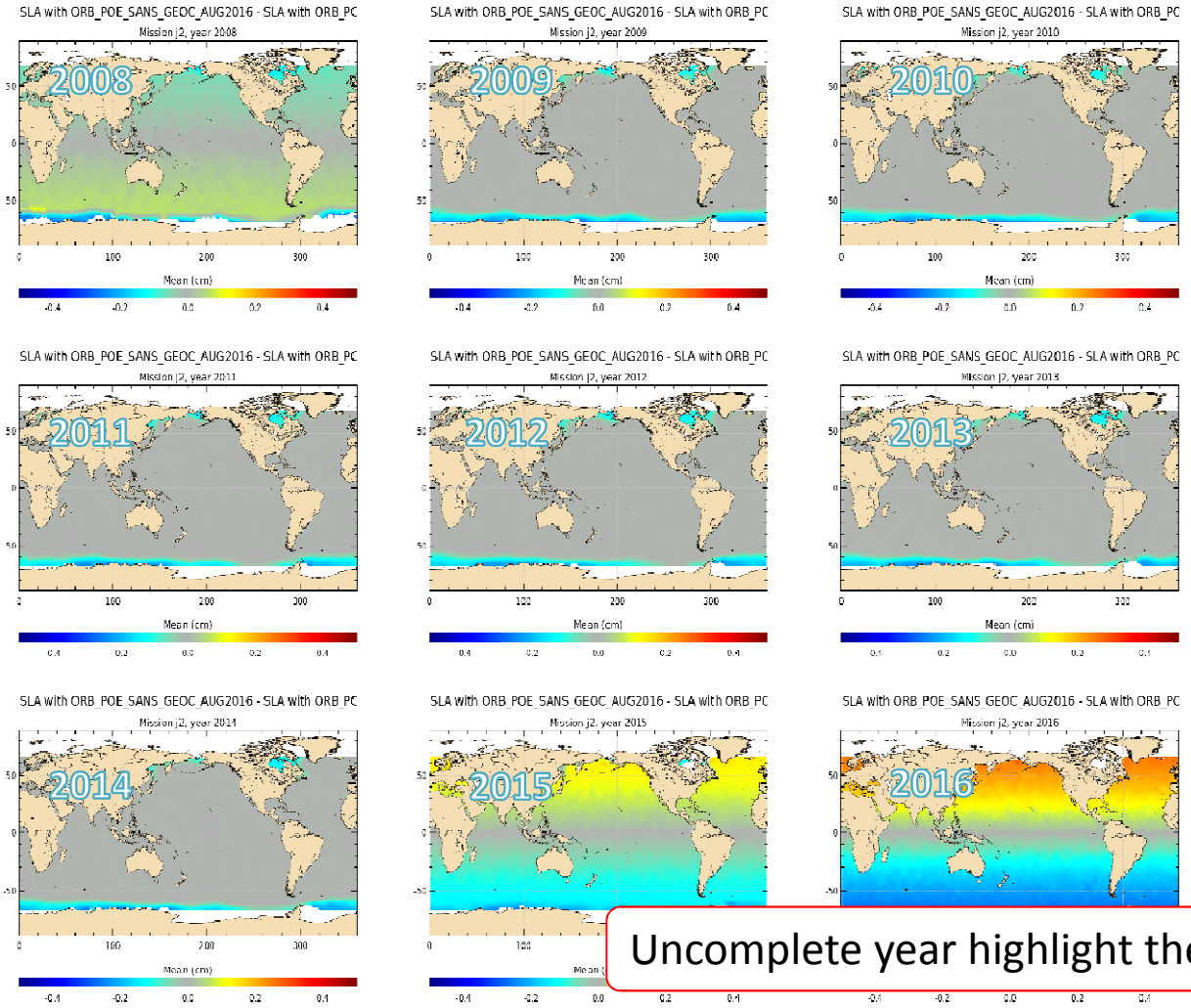
Negligible impact:

- No global trend difference
- No large scale effects on regional trend difference
- clear small annual signal

Effect of the orbit solution on Mean Sea Level Anomaly

Dynamic DORIS Ries - Dynamic DORIS No Geocenter

Mean Sea Level Anomaly differences

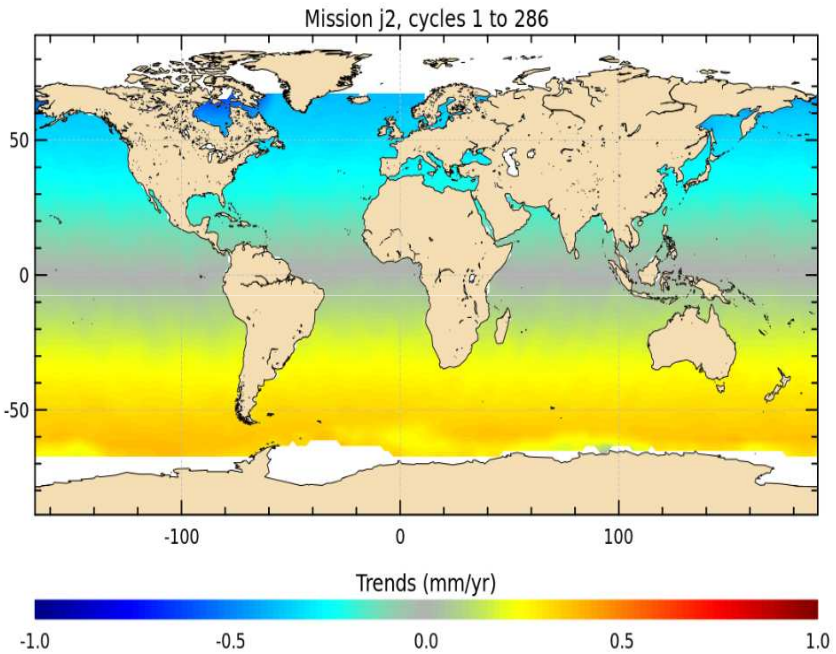


Uncomplete year highlight the annual signal

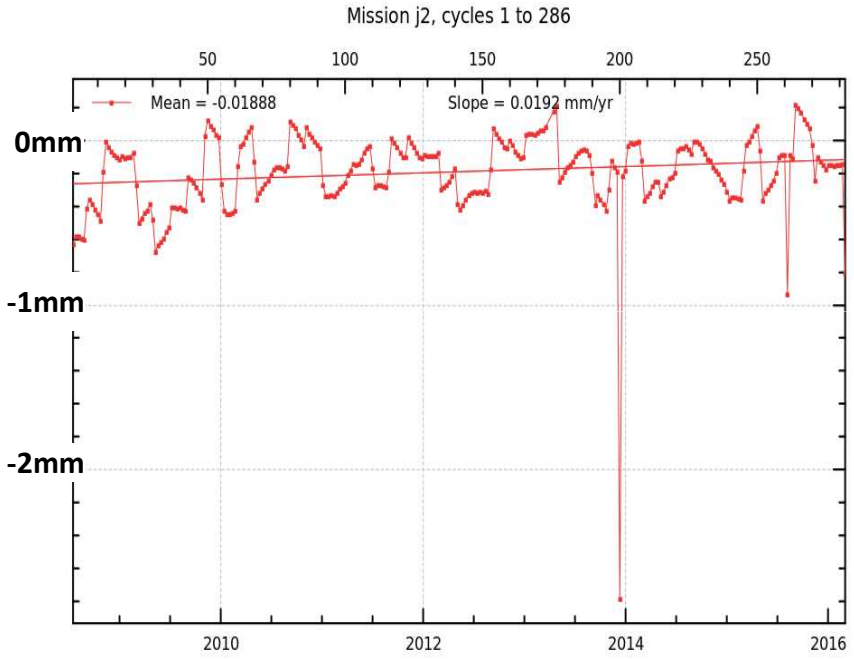
Effect of the orbit solution on Mean Sea Level Anomaly

Dynamic DORIS Ries - Dynamic DORIS Fiducial Free

Sea Level Anomaly trend differences



Mean Sea Level Anomaly differences



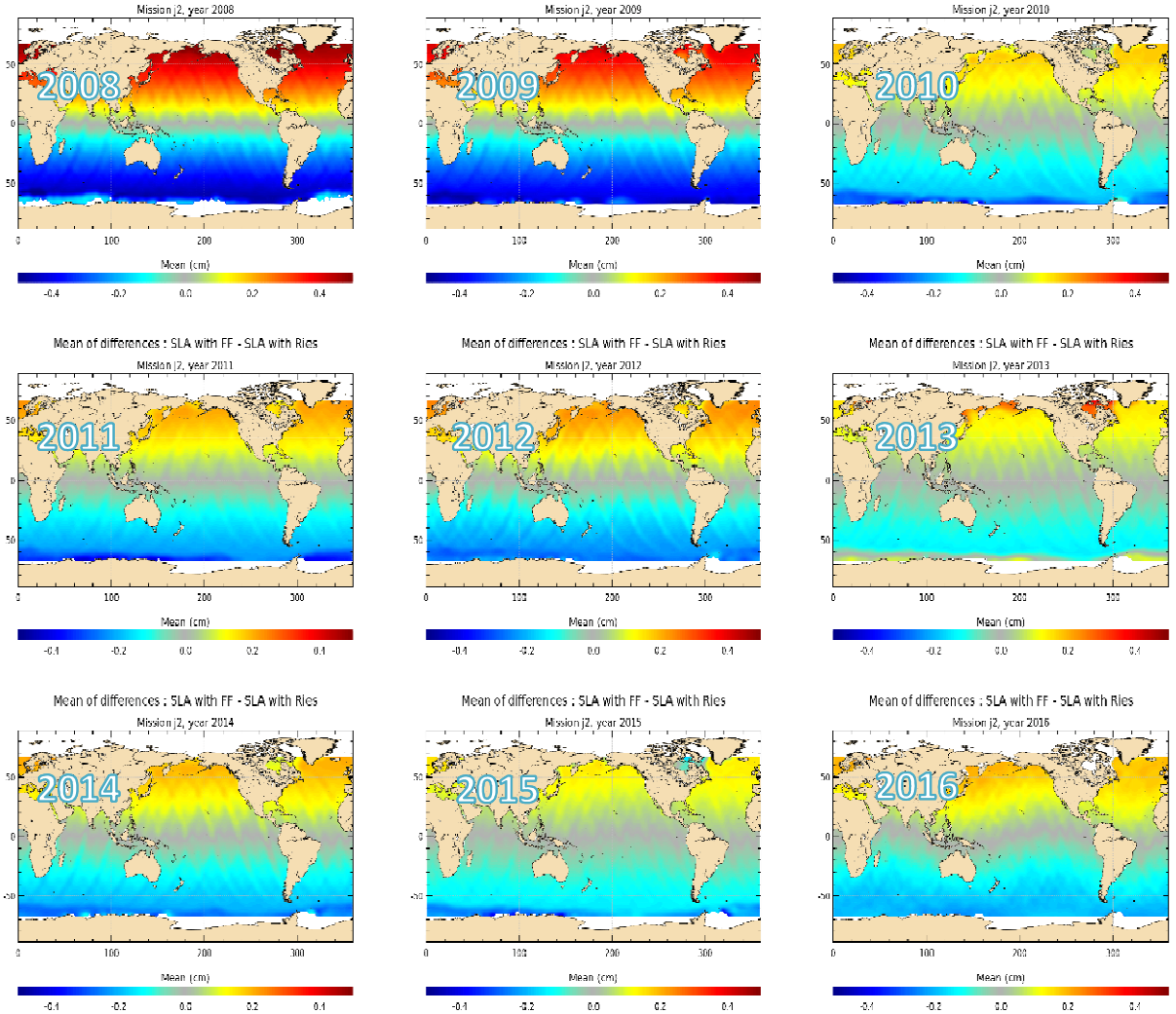
Significant impact:

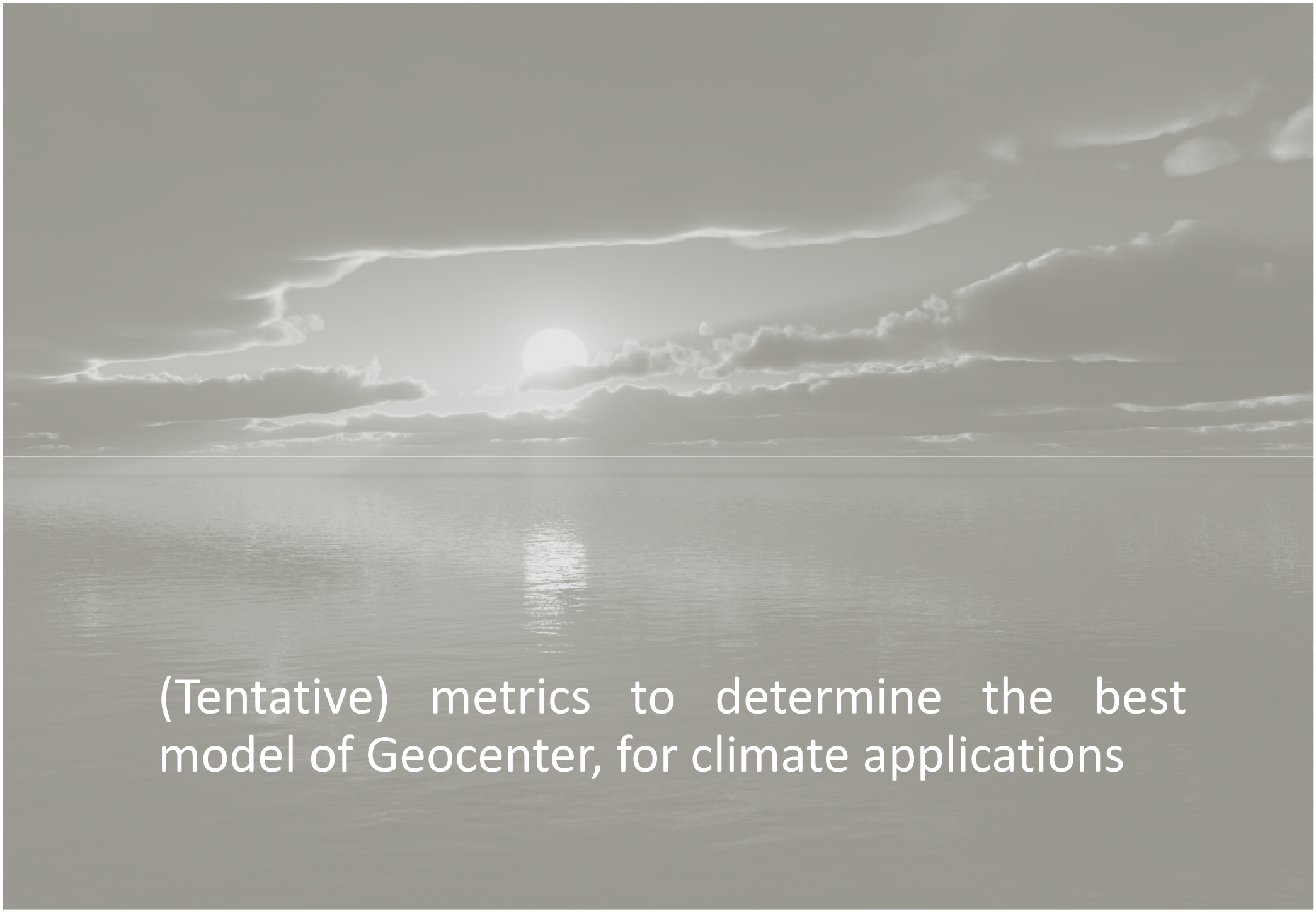
- No global trend difference but 0.8 mm.yr^{-1} N/S regional trend
- Clear North/South slighty variable in time cf. yearly average

Effect of the orbit solution on Mean Sea Level Anomaly

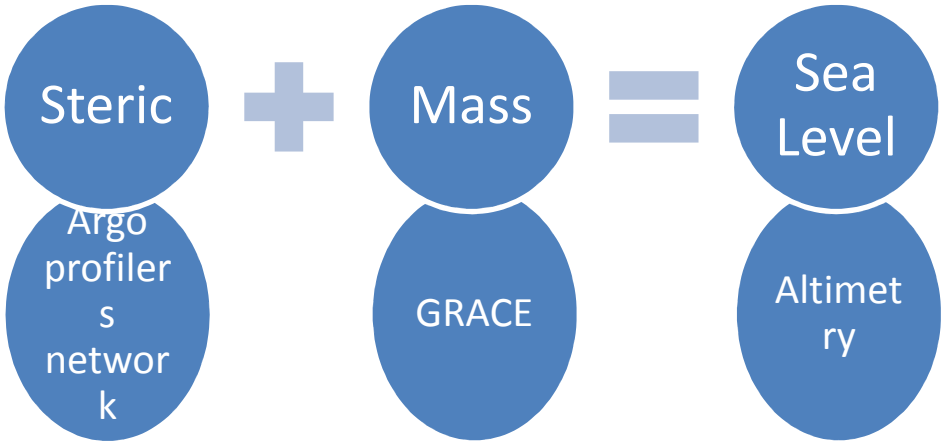
Dynamic DORIS Ries - Dynamic DORIS Fiducial Free

Mean Sea Level Anomaly differences




(Tentative) metrics to determine the best model of Geocenter, for climate applications

Effect of the orbit solution on Mean Sea Level



- Residuals SLA - Steric - Mass are usually a relevant metric to assess orbit quality (Couhert et al., 2015)
- However, Mass estimations from GRACE also suffer from geocenter motion (Swenson, 2008)

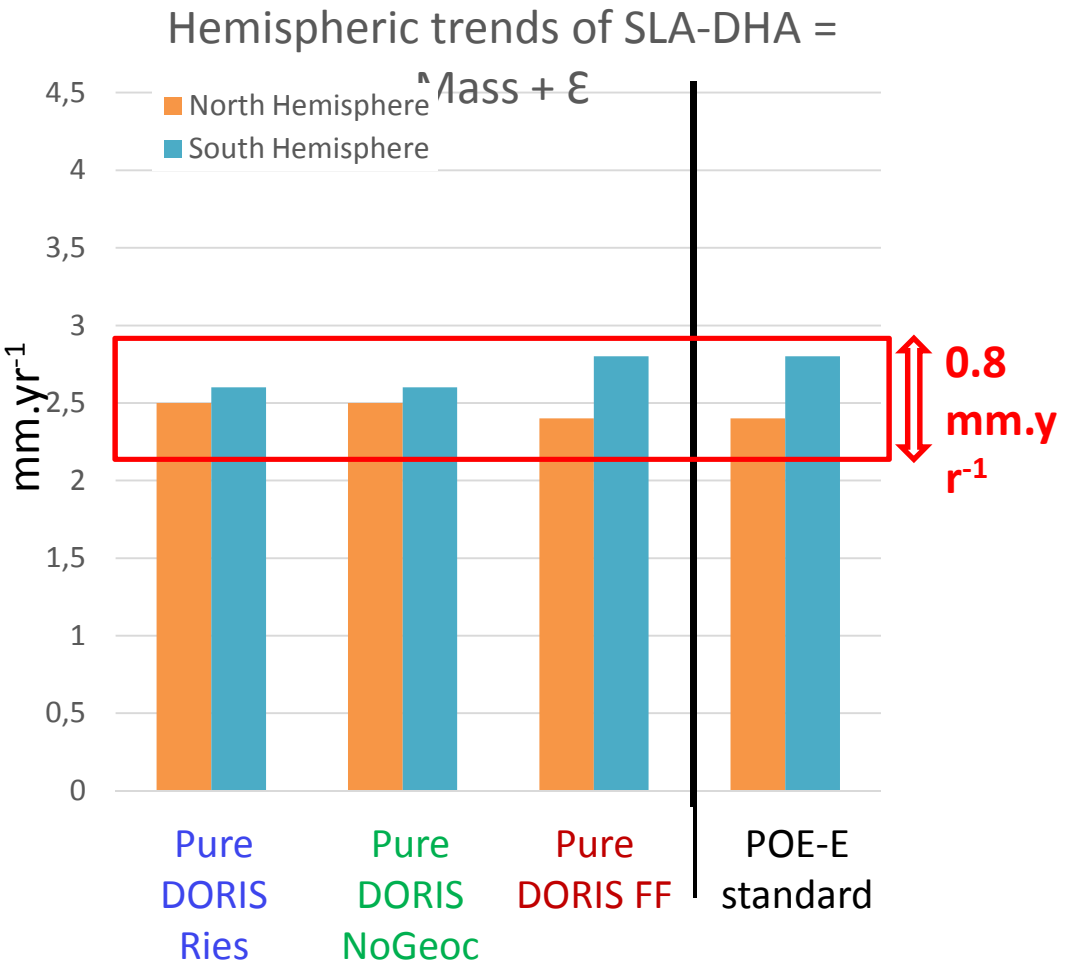
Effect of the orbit solution on Mean Sea Level

Approximation: Over a (very) large period

- **The map of mass-height-equivalent trends is theoretically uniform**
- The map of Dynamic Height Anomaly (DHA, steric) trends is theoretically uniform
- The map of Sea Level Anomaly (SLA) trends is theoretically uniform

In our case:

- The period is short (7 years) → Trend estimates may be impacted by interannual variations
- However, a first-order diagnosis is to compare the consistency between regional trends → here: North vs South
- **Large uncertainty with this method: ~0.8mm.yr^{-1}**



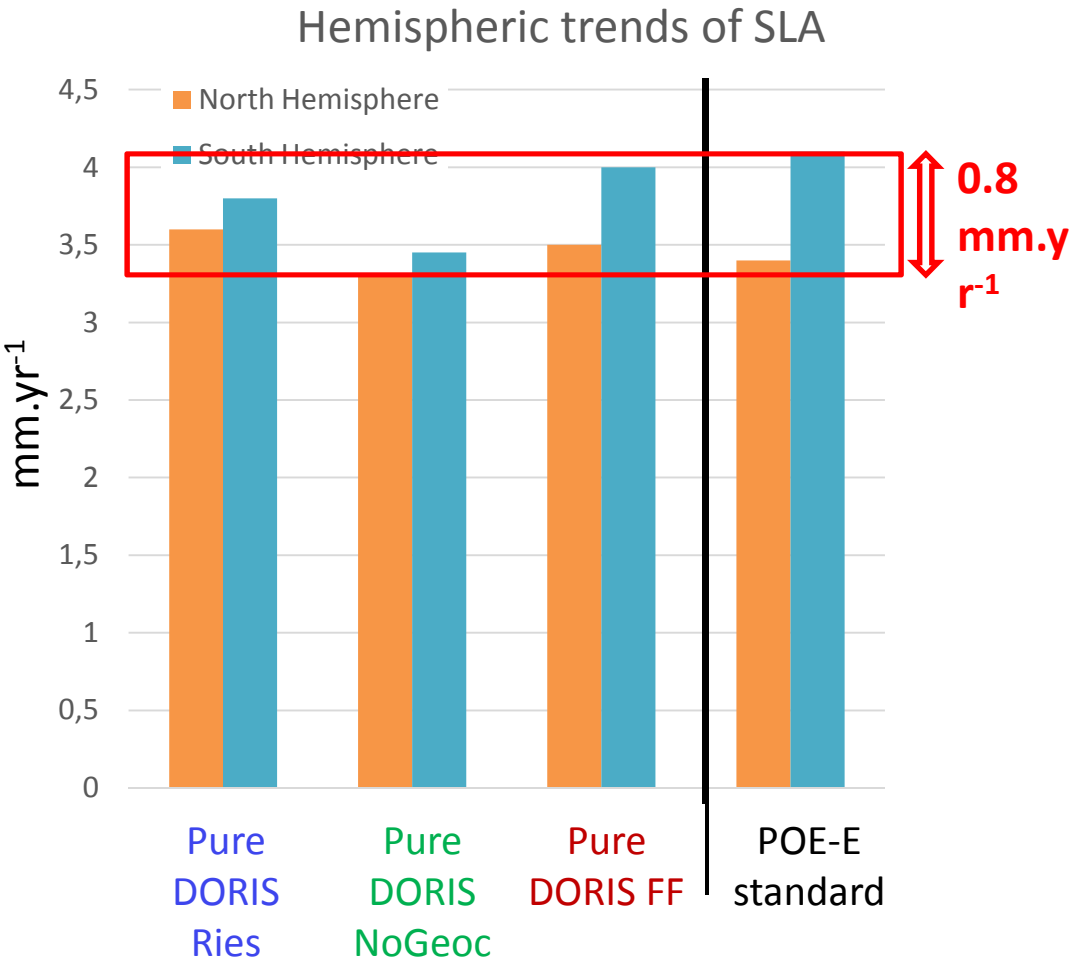
Effect of the orbit solution on Mean Sea Level

Approximation: Over a (very) large period

- The map of mass-height-equivalent trends is theoretically uniform
- The map of Dynamic Height Anomaly (DHA, steric) trends is theoretically uniform
- **The map of Sea Level Anomaly (SLA) trends is theoretically uniform**

In our case:

- The period is short (7 years) → Trend estimates may be impacted by interannual variations
- However, a first-order diagnosis is to compare the consistency between regional trends → here: North vs South
- **Large uncertainty with this method: ~0.8mm.yr^{-1}**




Conclusions

Conclusions

Changing the geocenter position model has a hemispheric ~1 mm.yr^{-1} impact in orbits (= order of magnitude of the precision required for climate studies)

The discrepancies induced by a **change of geocenter** is of a **similar order** of magnitude as changing the **POD estimation method** (impact of GPS and reduced dynamics) that can hardly be totally separated from the geocenter modelling itself.

The analysis performed here also showed a non negligible effect of the **annual signal**. This needs further investigations.

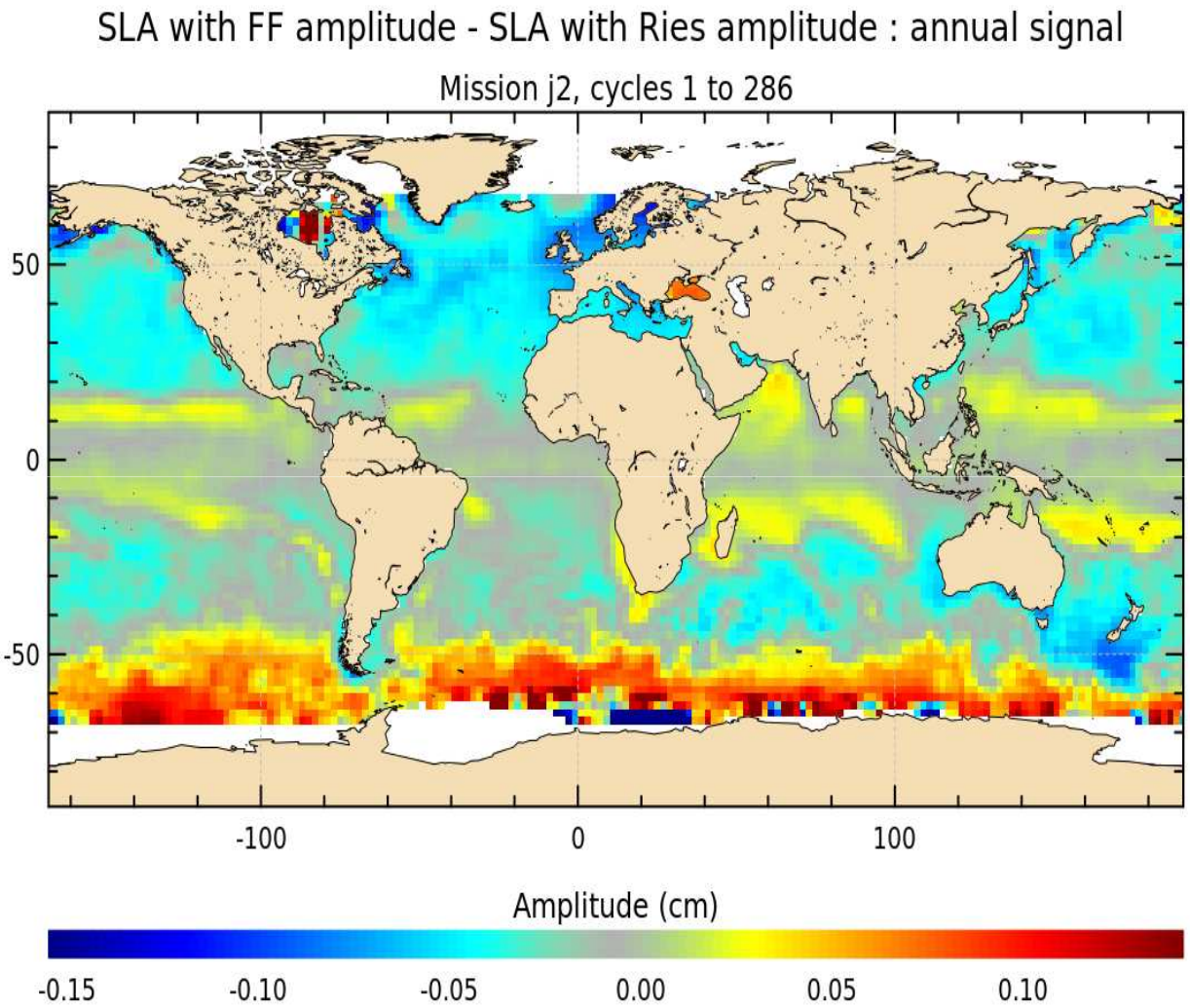
Deciding **which solution is the best remains challenging** because it reaches the level of precision of the methods based on SLA or in situ comparisons

Still, the **rather theoretical** issue addressed here raises interesting perspectives to improve the diagnosis that enable to validate orbital solutions with altimetry.

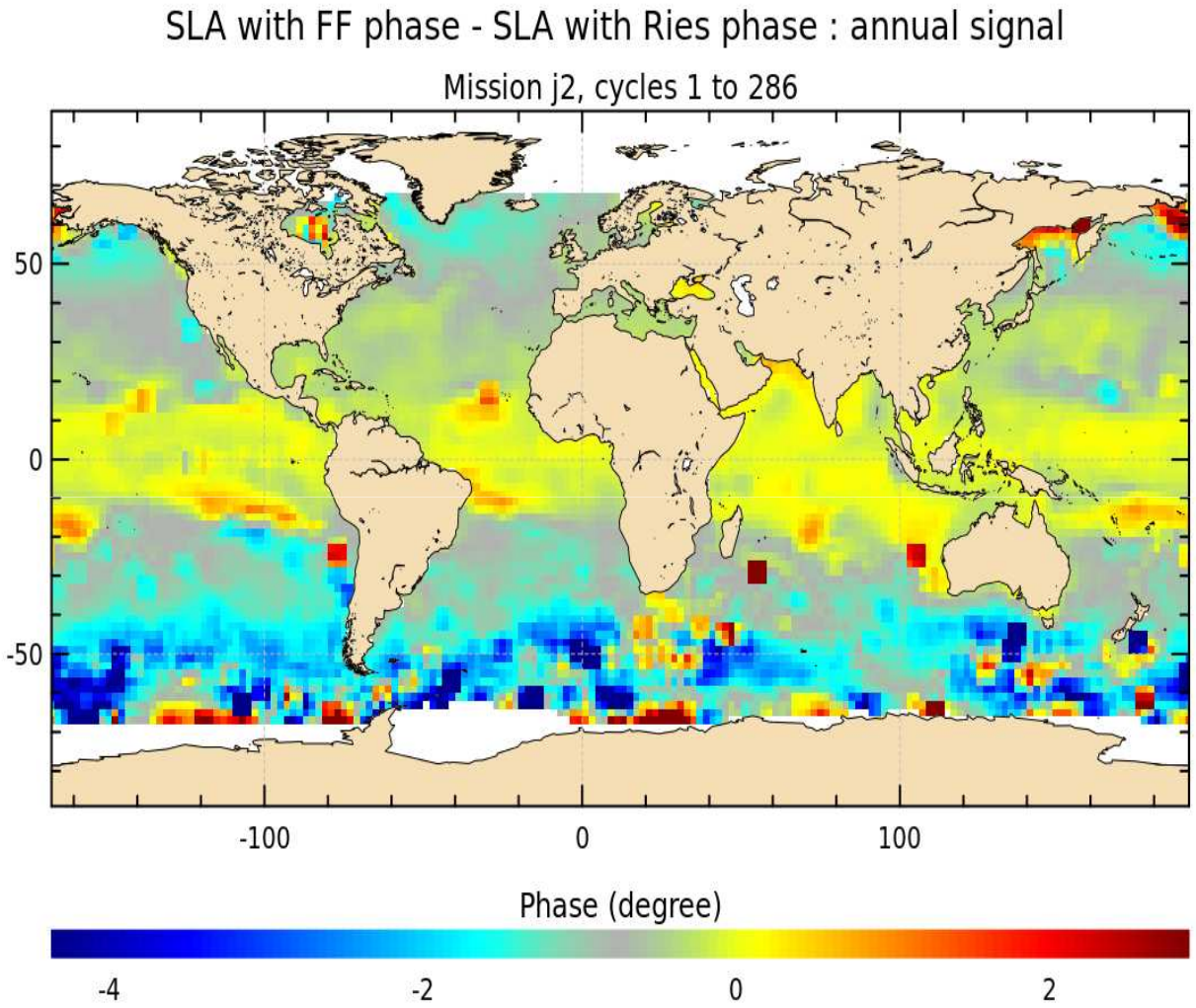
Thank you for your attention

Annabelle.Ollivier@cls.fr Lionel.Zawadzki@cls.fr

Back up


SLA with FF amplitude - SLA with Ries amplitude : annual signal
Mission j2, cycles 1 to 286
50
0
-50
-100
0
100
Amplitude (cm)
-0.15
-0.10
-0.05
0.00
0.05
0.10

Back up


SLA with FF phase - SLA with Ries phase : annual signal
Mission j2, cycles 1 to 286
50
0
-50
-100
0
100
Phase (degree)
-4
-2
0
2