Non-closure of the global mean sea level budget since 2016: contributions of altimetry and Argo

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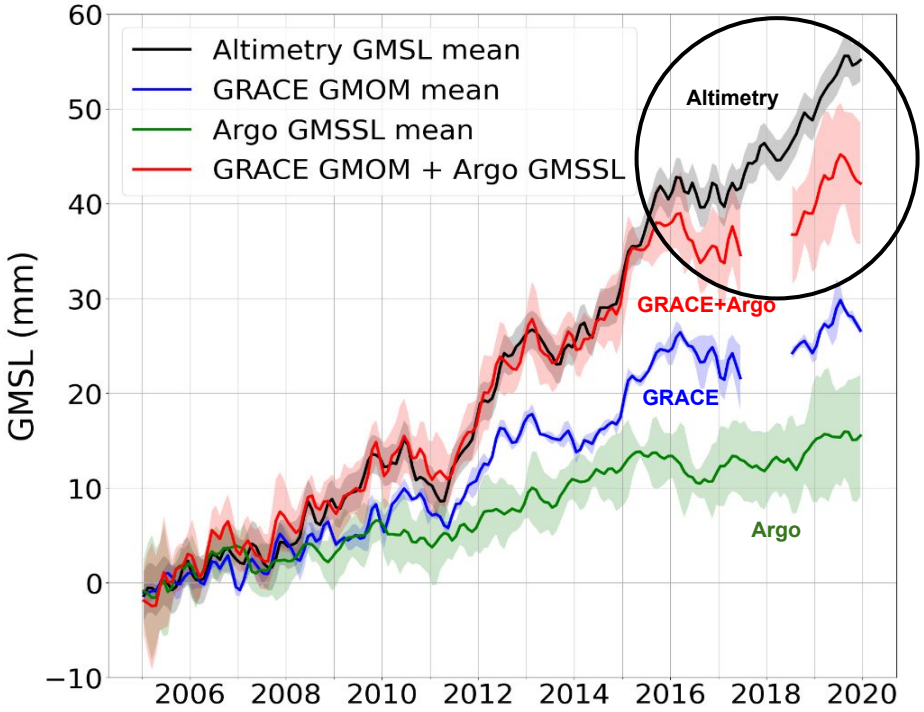
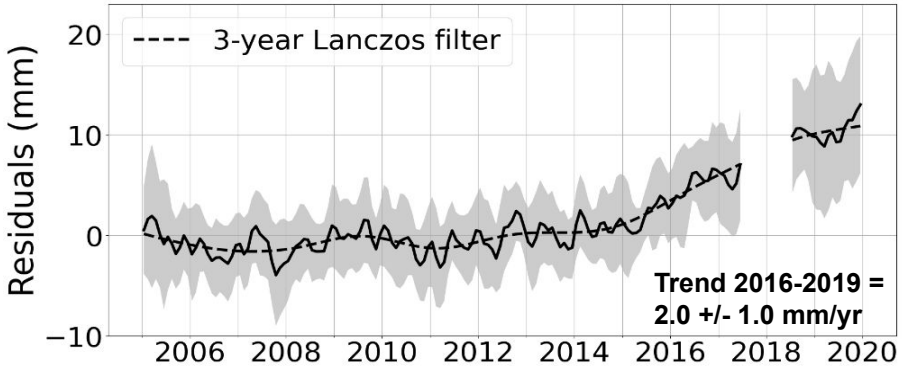
Global mean sea level budget

ΔSL = ΔOM + ΔSSL

ΔGMSL = ΔGMSSL + ΔGMOM



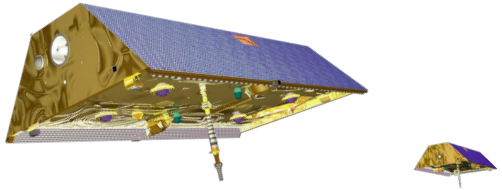


- The sea level budget was closed from 1993 to 2015 (e.g. Horwath et al., 2022). Since 2015, the budget is no longer closed (Chen et al., 2020, Barnoud et al., 2021).

➔ Which sources of errors in any of the three components are responsible for the observed non-closure?

Investigating the gravimetry OM component

ΔSL = ΔOM + ΔSSL

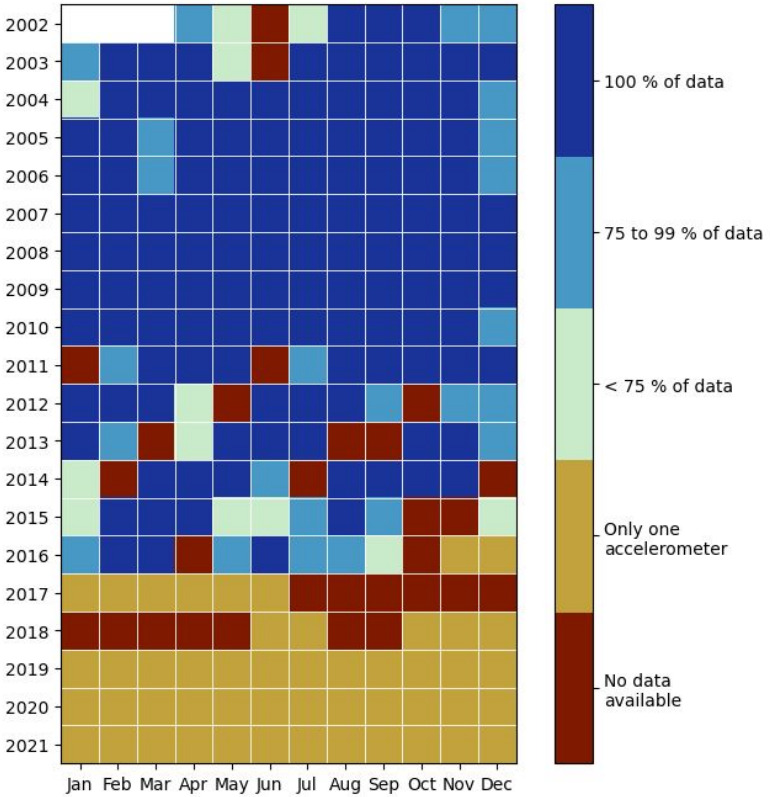


- From 2015, instrumental issues have affected the GRACE and GRACE-FO spacecrafts (battery power failures and loss of one of the two accelerometers).

- The change between the two GRACE and GRACE-FO missions could lead to a possible inter-mission bias even though no bias have been detected up to now (e.g. Velicogna et al., 2020; Landerer et al., 2020).

GRACE/GRACE Follow-On data availability

(updated from Blazquez, 2020)

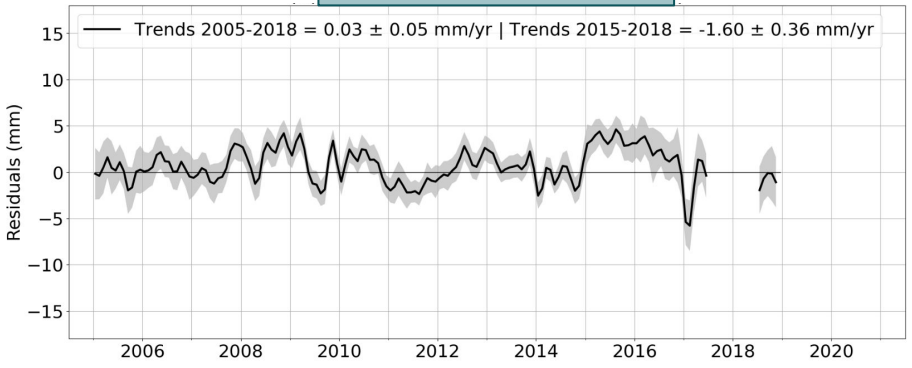


Investigating the gravimetry OM component

$\Delta SL = \Delta OM + \Delta SSL$

Ocean mass budget

Residuals

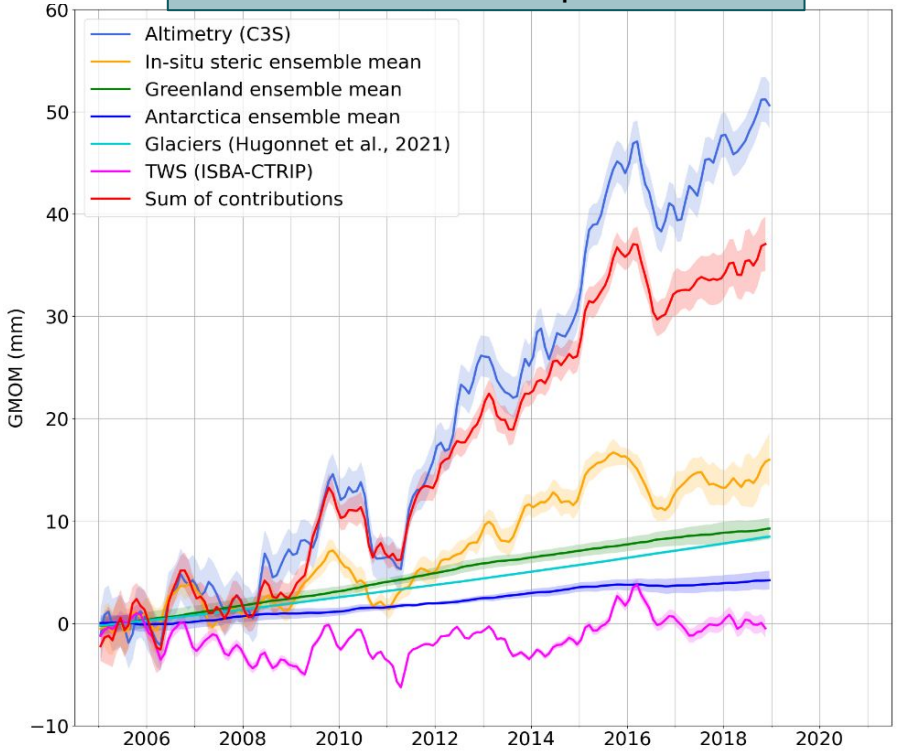


- A residual trend of **-1.6 +/- 0.4 mm/yr** over 2015-2018 is observed.
- Large uncertainties are associated with the terrestrial water storage variations.

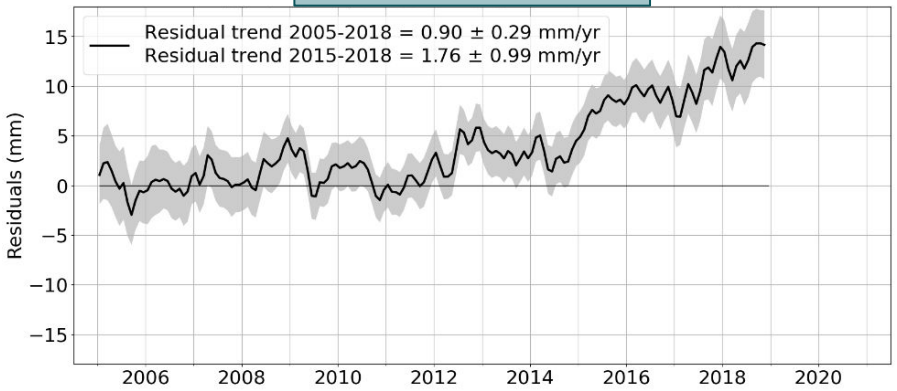
Investigating the gravimetry OM component

$\Delta SL = \Delta OM + \Delta SSL$

Sea level budget with the sum of ocean mass components



Residuals

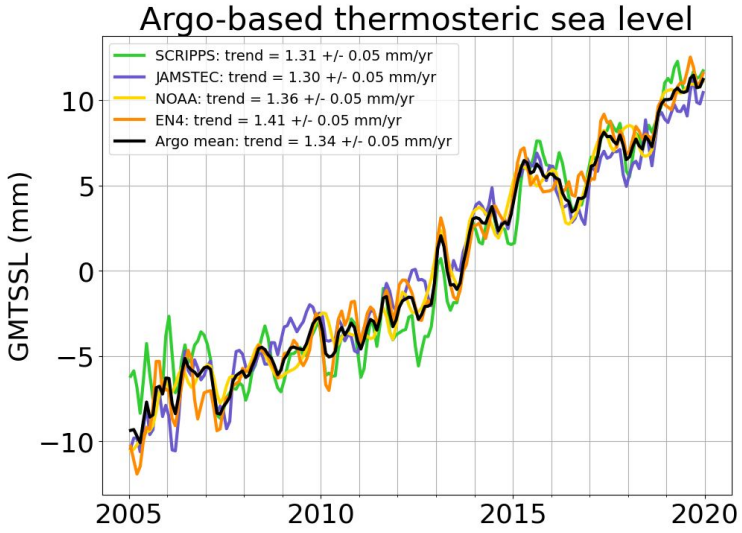


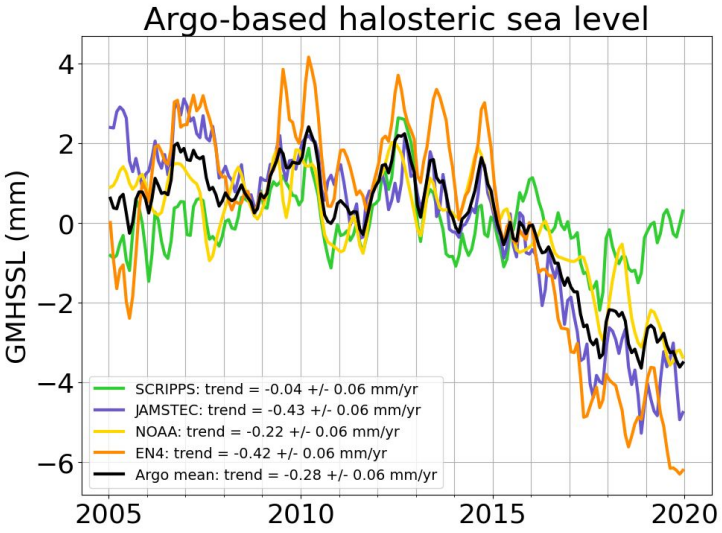
Replacing the ocean mass component by the sum of the individual mass contributions (**estimated independently from GRACE/GRACE-FO data**), the sea level budget is not closed either.

➔ There are errors is some other components of the budget (altimetry, thermosteric, TWS, missing contributions).

Investigating the in-situ steric component

ΔSL = ΔOM + ΔSSL



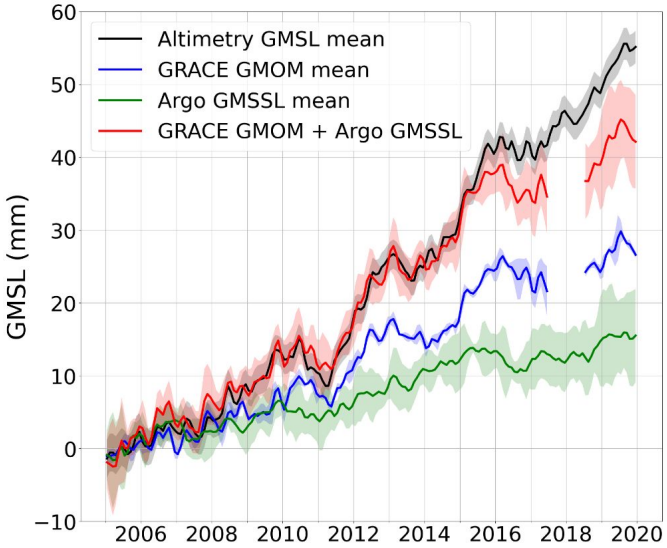


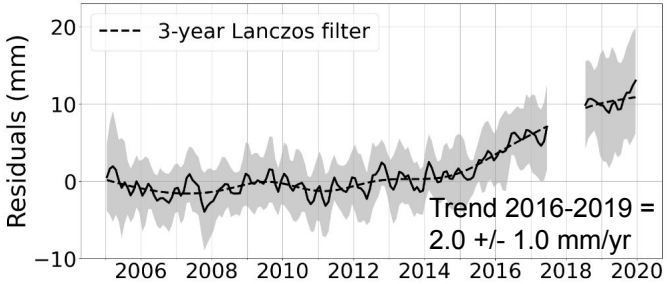
➔ A drop in the halosteric sea level is due to drifts in salinity measurements of the Argo float (Wong et al., 2020).

Investigating the in-situ steric component

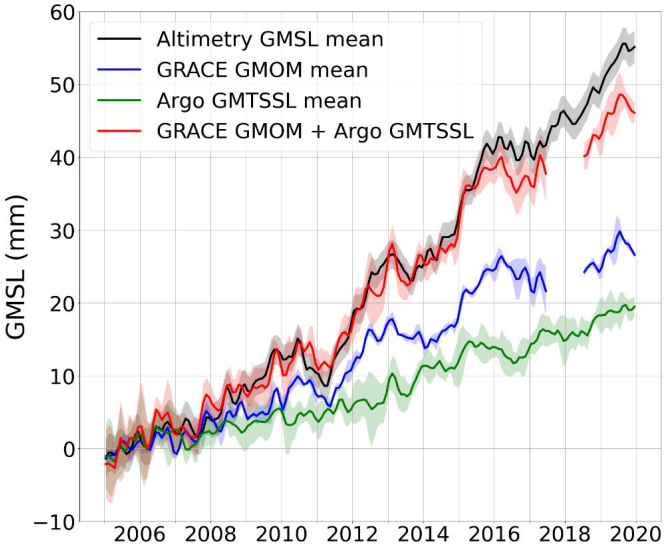
$\Delta SL = \Delta OM + \Delta SSL$

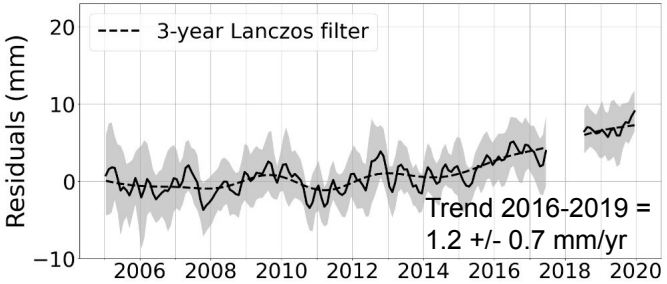
Using the total steric sea level





Using the thermosteric sea level



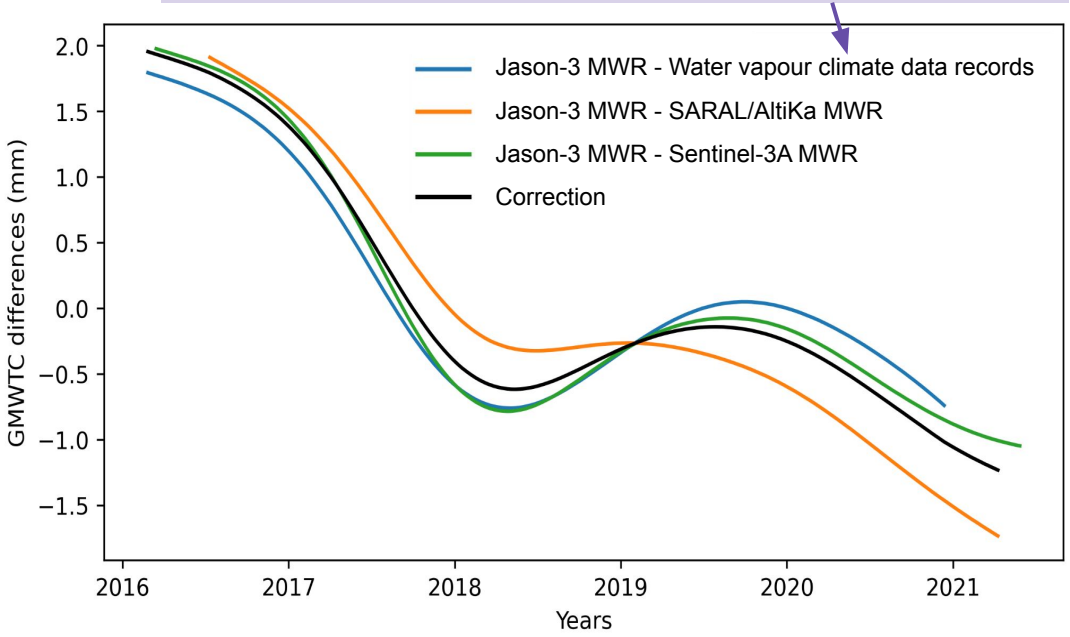


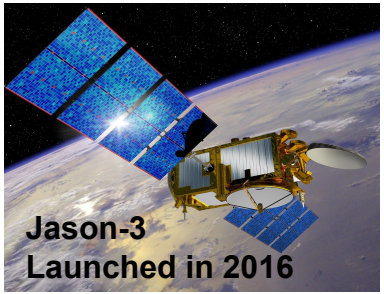
Investigating the altimetry SL component

ΔSL = ΔOM + ΔSSL

The global mean **wet tropospheric correction** (GMWTC) from Jason-3 is compared with independent data.

See presentation on Thursday: “Improving long term estimates of global mean sea level using water vapour climate data records”, Barnoud et al.



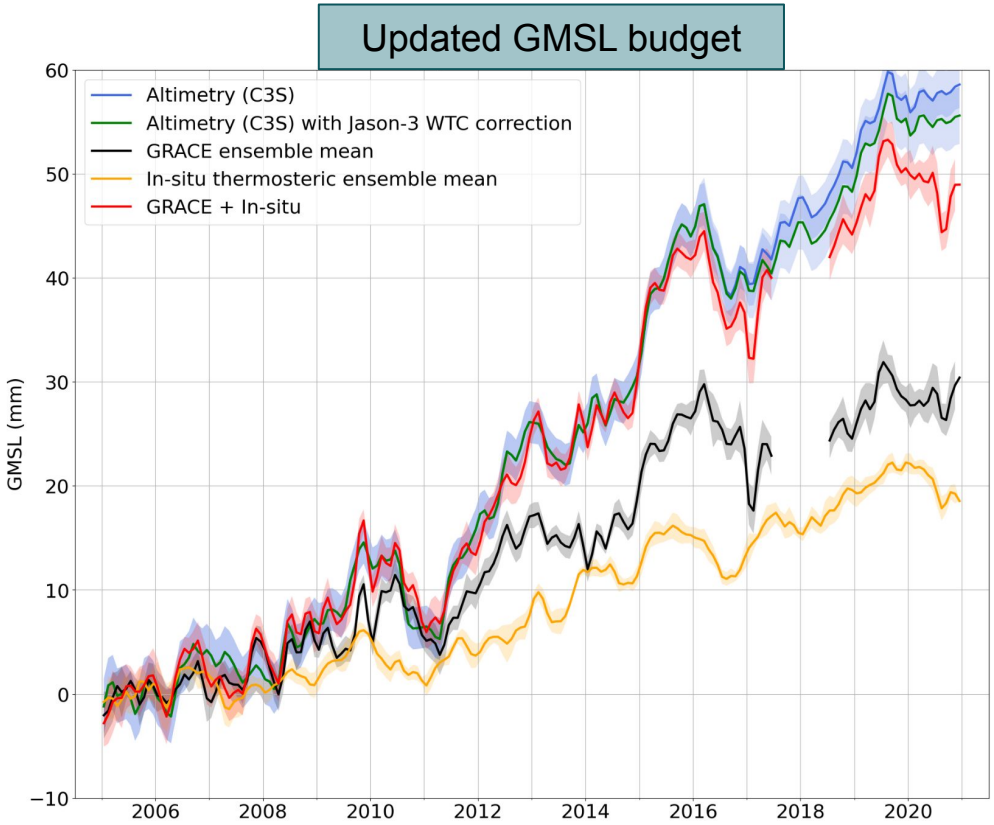


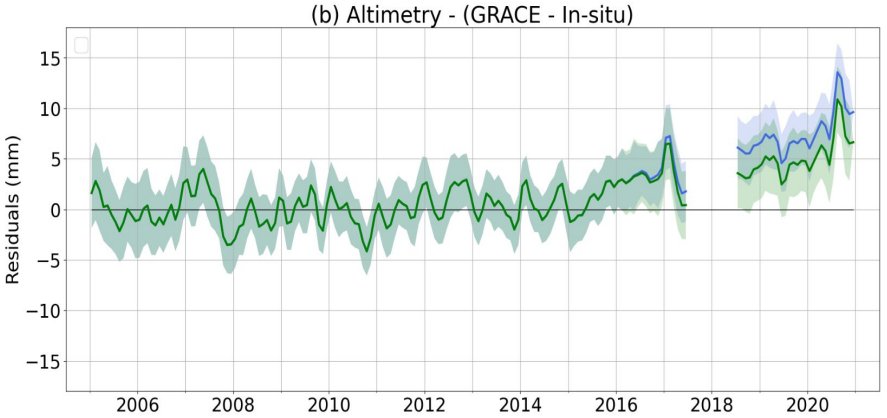
➔ We detect a **significant drift** of Jason-3 radiometer GMWTC of about **-0.5 mm/yr**.

➔ We estimate a non-linear **empirical correction** from the GMWTC differences.

Investigating the altimetry SL component

ΔSL = ΔOM + ΔSSL



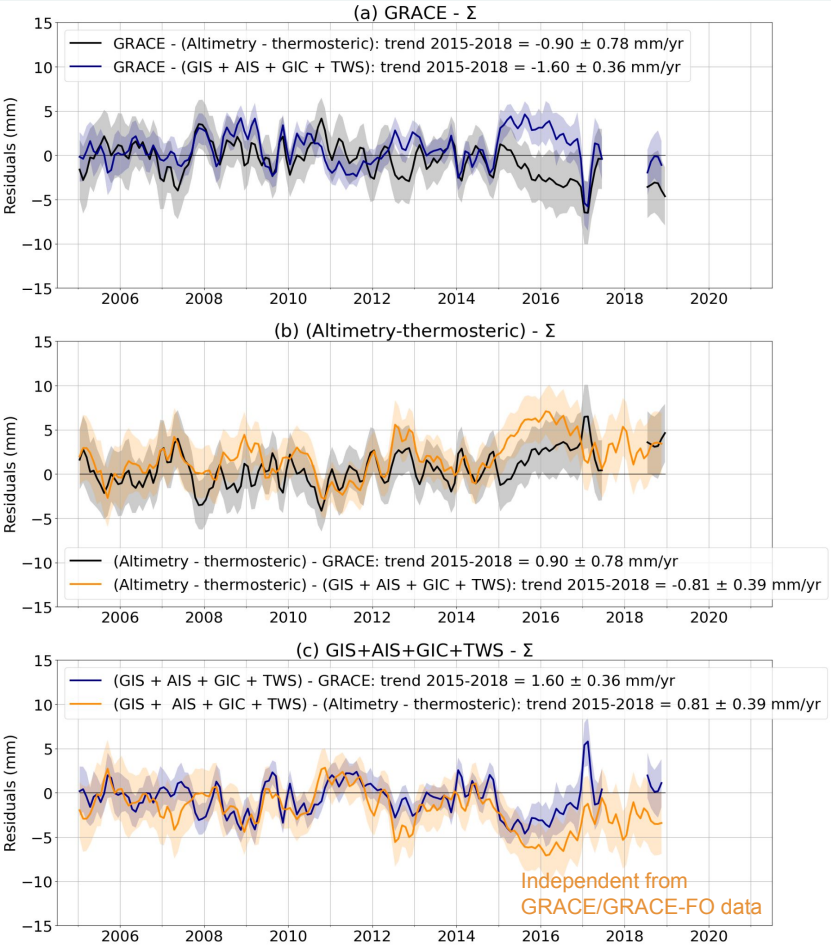


- The residual trend over 2015-2020 amounts to
  - 1.5 +/- 0.4 mm/yr before correction
  - 1.0 +/- 0.5 mm/yr after correction.

➔ The budget residual trend is reduced when correcting for Jason-3 drift but remains significant.

Summary of corrected budget residuals

$\Delta SL = \Delta OM + \Delta SSL$



Significant residuals remain after 2015 in all three budget configurations:

- GRACE - Altimetry - Argo thermosteric
- GRACE - land ice & water models
- Altimetry - Argo - land ice & water models

These residuals:

➔ may be partly (but not fully) due to the GRACE and GRACE-FO based global mean ocean mass,

➔ are due to errors in at least two components of the budgets (including missing contributions),

➔ certainly result from a combination of errors with different behaviours (e.g. linear drift, offset, interannual variations).

Conclusions and outlook

ΔSL = ΔOM + ΔSSL

- **Conclusions**
  - A **salinity** drift is responsible for ~40% of the non-closure of the global mean sea level budget.
  - A drift in **Jason-3** radiometer wet tropospheric correction has been identified and must be corrected for climate studies. It is responsible for ~30 % of the non-closure of the budget.
  - The remaining non-closure is due to errors in **at least two components** of the budgets (e.g., gravimetry, altimetry, Argo thermosteric, TWS, missing contributions), to be further investigated.

- **Outlook**
  - Future works include assessing the budget at regional scale.
  - The use of forthcoming updated data should improve the results.

Thank you for your attention.

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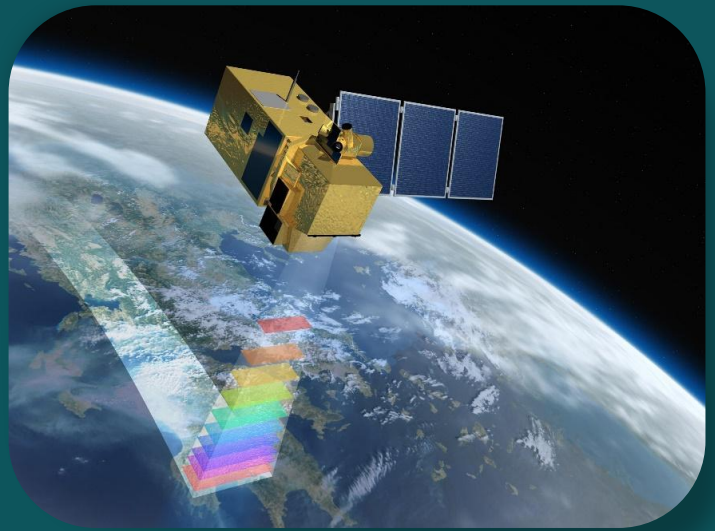

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  - Barnoud, A., Picard, B., Meyssignac, B., Marti, F., Ablain, M. and Roca, R. (submitted). Reducing the long term uncertainties of global mean sea level trend using highly stable water vapour climate data records.

- Global mean ocean mass budget and Jason-3 wet tropospheric correction drift
  - Barnoud, A., Pfeffer, J., Cazenave, A. and Ablain, M. (in revision). Revisiting the global mean ocean mass budget over 2005-2020. https://doi.org/10.5194/egusphere-2022-716