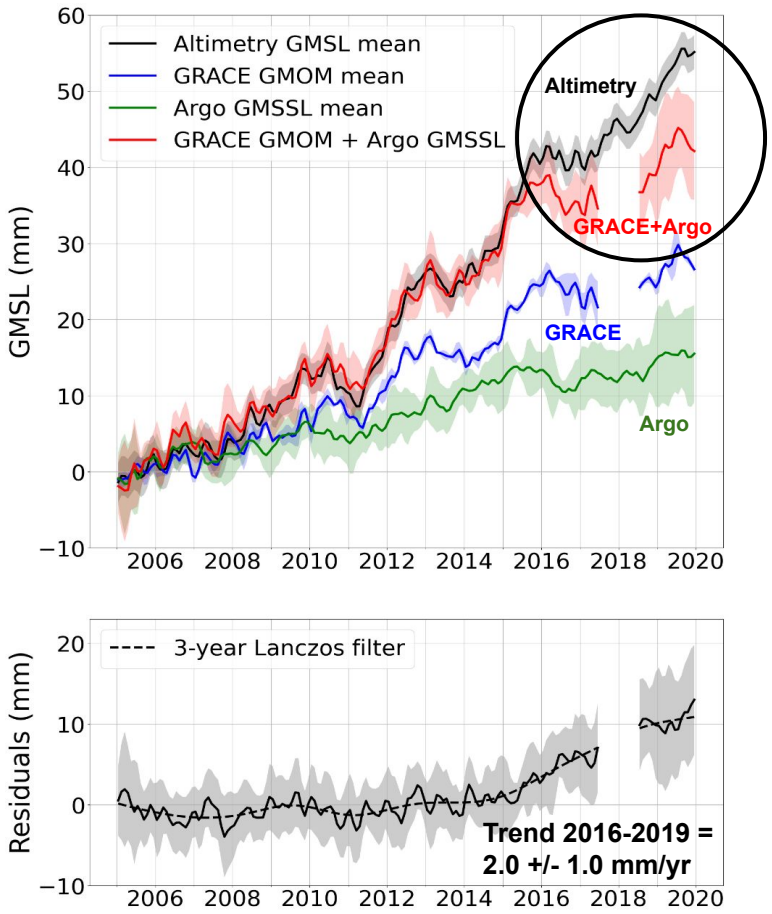
Non-closure of the global mean sea level budget since 2016: contributions of altimetry and Argo

Anne Barnoud[1*], **Julia Pfeffer**[1], Adrien Guérou[2], Marie-Laure Frery[2], Mathilde Siméon[2], Anny Cazenave[1,3], Jianli Chen[4], William Llovel[5], Virginie Thierry[5], Jean-François Legeais[2], Michaël Ablain[1]

[1]Magellium, Toulouse, France; [2]CLS, Toulouse, France; [3]LEGOS, Toulouse, France;
[4]CSR, Austin, USA; [5]LOPS, Plouzané, France
*anne.barnoud@magellium.fr

Global mean sea level budget

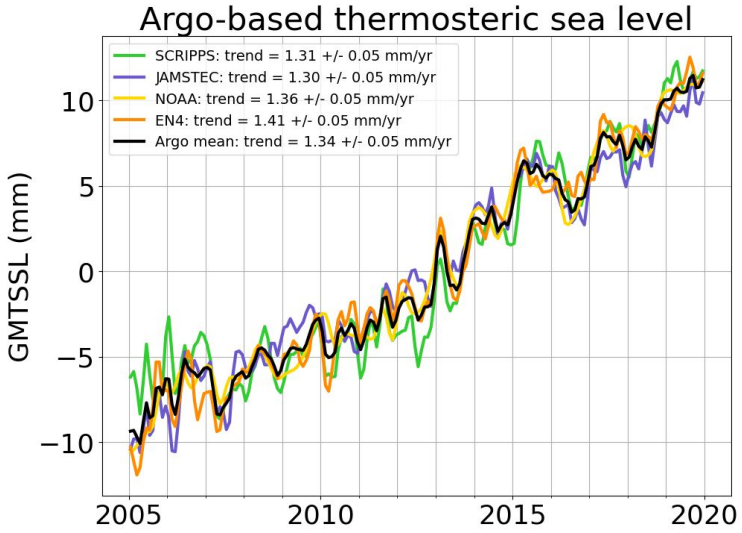


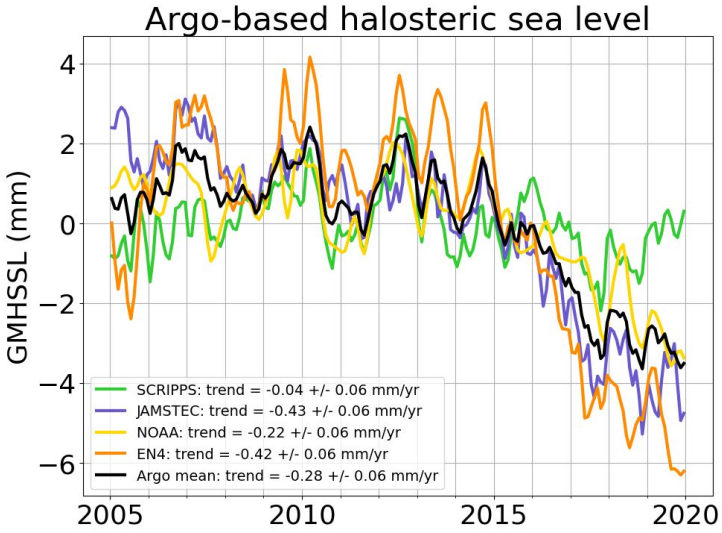
ΔGMSL = ΔGMSSL + ΔGMOM

- **GMSL**: global mean sea level
- **GMSSL**: global mean steric sea level (thermosteric + halosteric)
- **GMOM**: global mean ocean mass

- The sea level budget was closed from 1993 to 2016 (e.g. Horwath et al., 2022). Since 2016, the budget is no longer closed (Chen et al., 2020).
- Which sources of errors in any of the three components are responsible for the observed non-closure?
- GRACE/GRACE-FO have encountered several instrumental issues. However, potential errors in altimetry and Argo data could also be responsible for the observed non-closure.

Argo-based global mean steric sea level

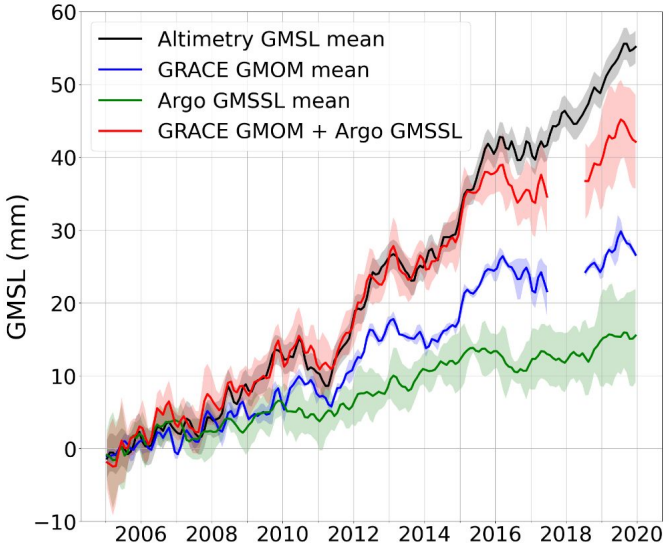


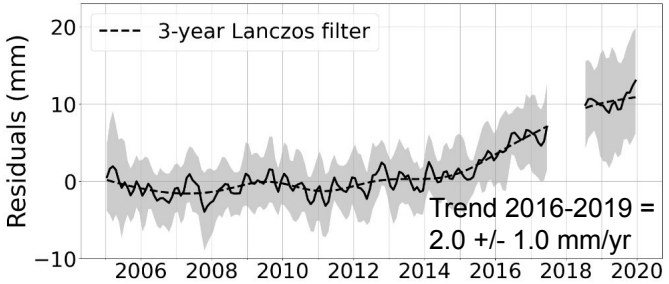


➔ A drop in the halosteric sea level is due to drifts in salinity measurements of the Argo float (Wong et al., 2020).

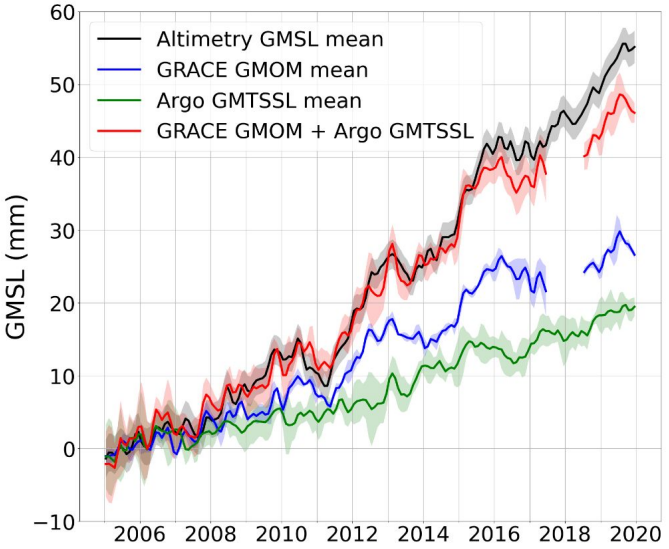
Updated GMSL budget

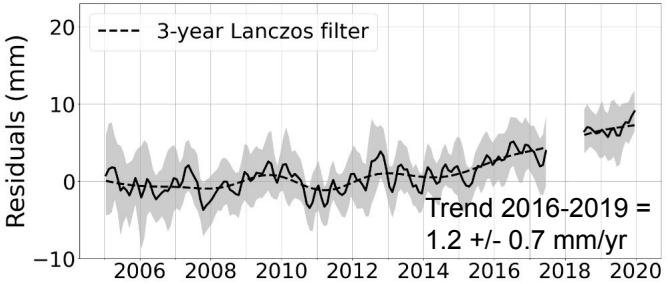
Using the total steric sea level





Using the thermosteric steric sea level

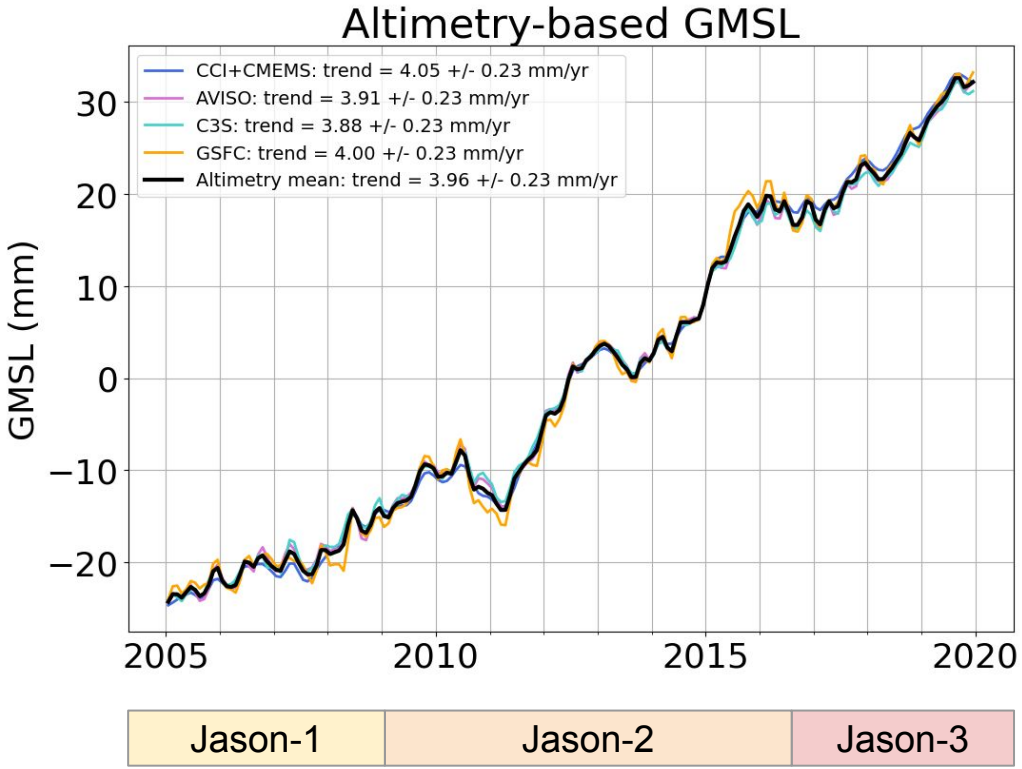




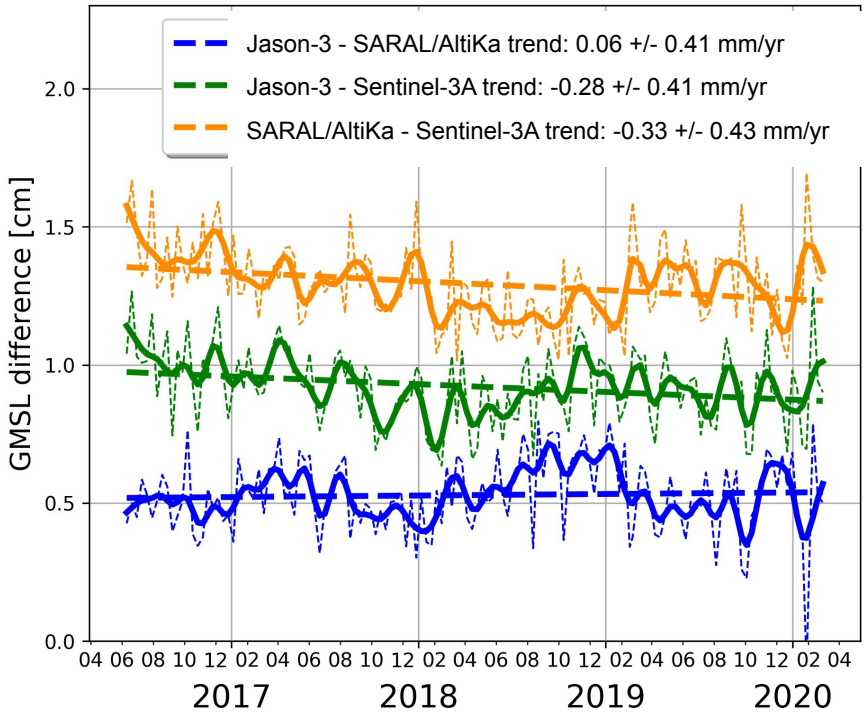
Altimetry-based global mean sea level

- Jason-3 was launched in 2016.
- Two instruments are onboard altimetry satellites:
  - altimeter,
  - radiometer to correct for the wet troposphere.

➔ We assess the stability of both the altimeter and radiometer of Jason-3.



Jason-3 altimeter stability



- We compare the GMSL of simultaneous altimetry missions.

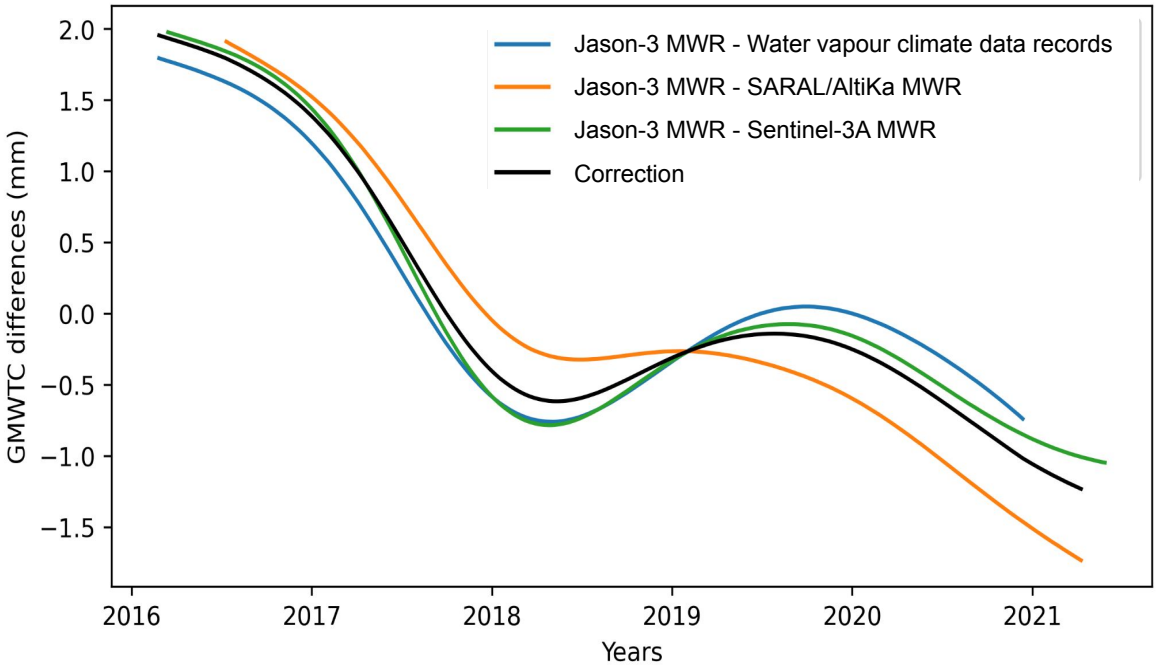
➔ No significant relative drift is detected within a standard uncertainty of 0.4 mm/yr.

Jason-3 radiometer stability

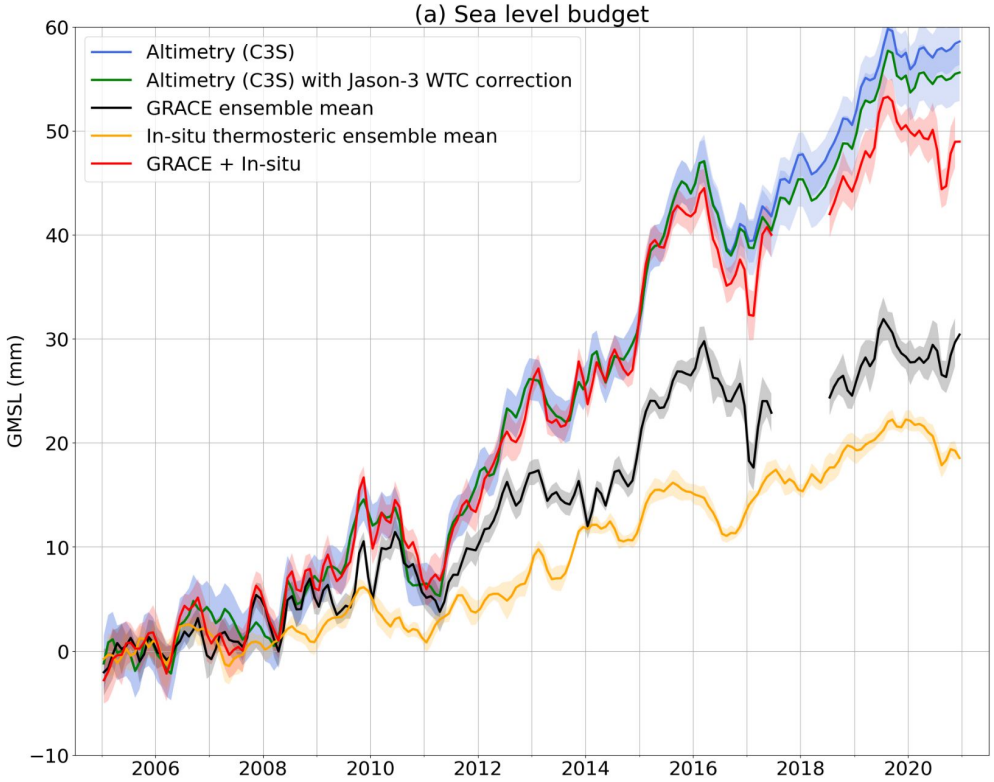
- The global mean wet tropospheric correction (GMWTC) from Jason-3 is compared with independent data.

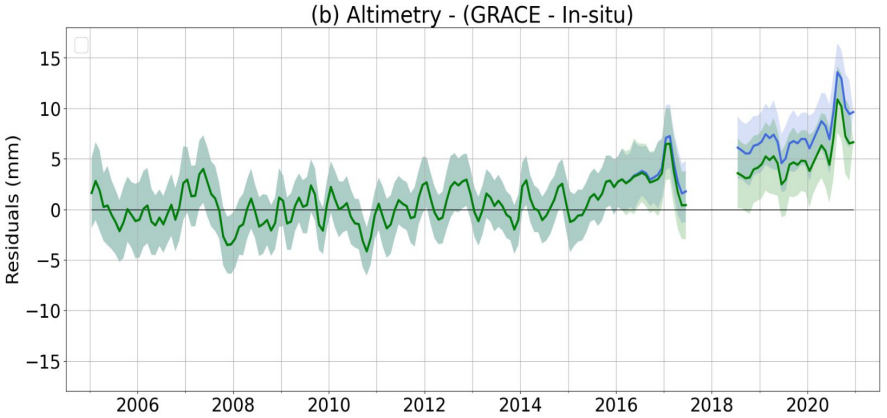
➔ We detect a drift of Jason-3 radiometer of about 0.5 mm/yr.

➔ We estimate an empirical correction from the GMWTC differences.



Updated GMSL budget





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

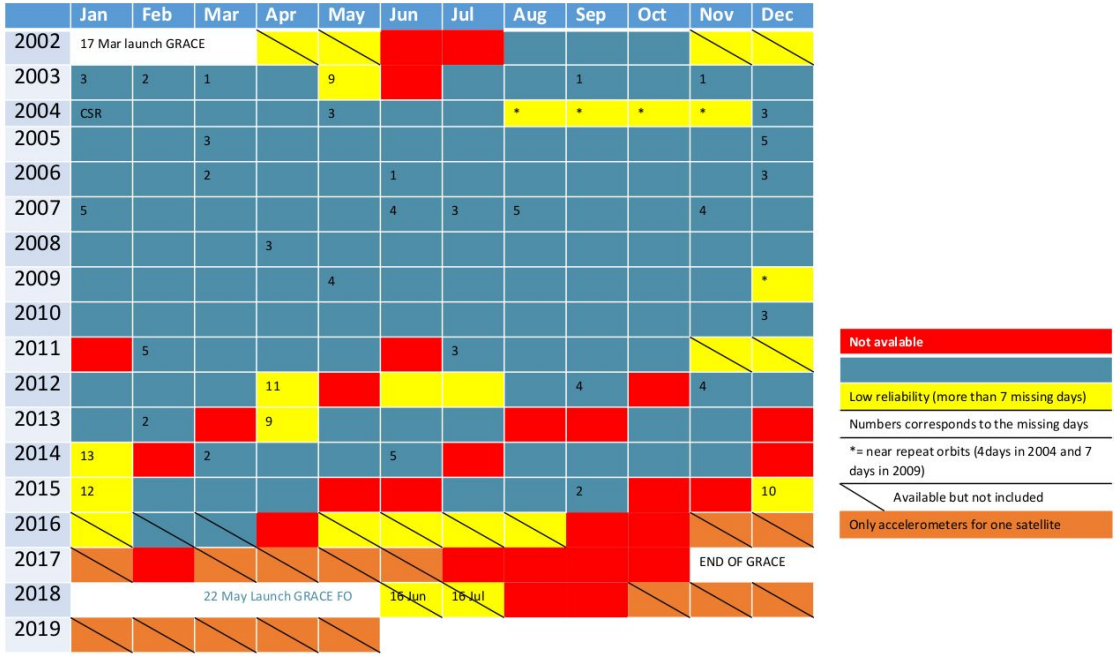
➔ The budget residual trend is reduced when correcting for Jason-3 drift but remains significant.

GRACE and GRACE Follow-on data

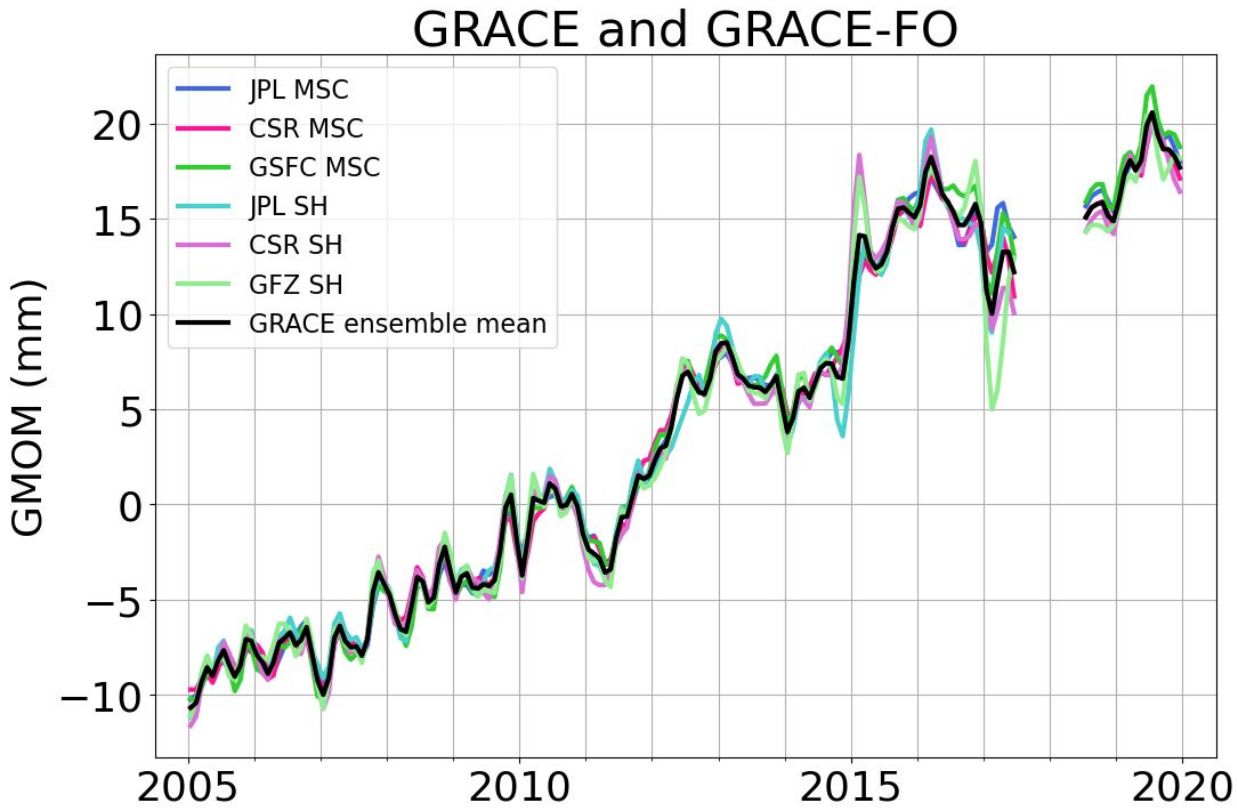
- From 2015, instrumental issues have affected the GRACE and GRACE-FO spacecrafts (battery power failures and loss of one of the two accelerometers).

- 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 reliability and availability
(Alejandro Blazquez, PhD thesis, 2020)



GRACE and GRACE-FO global mean ocean mass



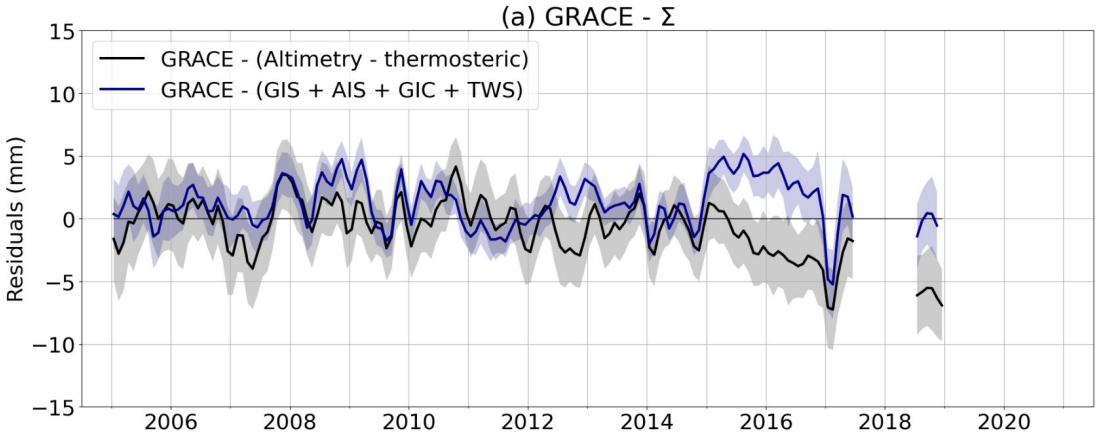
Ocean mass budget

Ocean mass change
=
Greenland
+
Antarctica
+
glaciers
+
terrestrial water storage

- The GRACE and GRACE Follow-on-based global mean ocean mass is compared to the individual contributions.

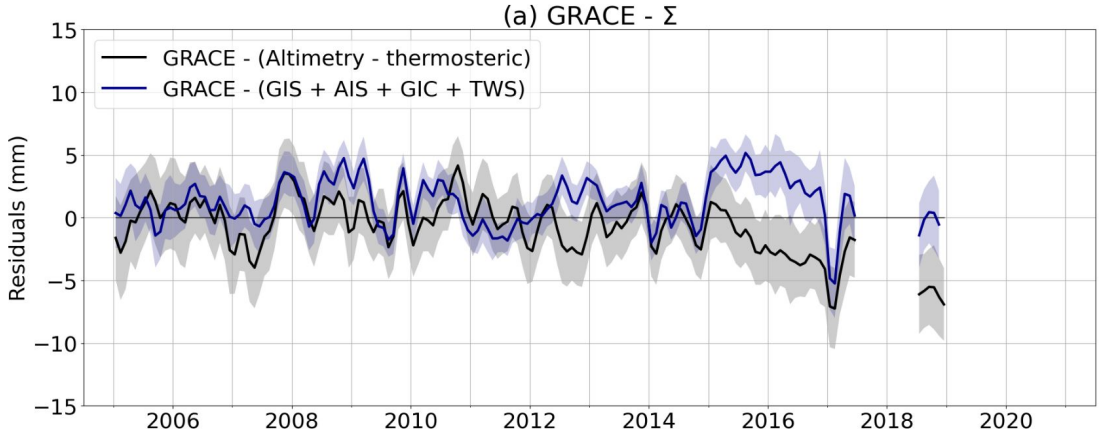
➔ A residual trend of -1.6 +/- 0.4 mm/yr over 2015-2018 is observed.

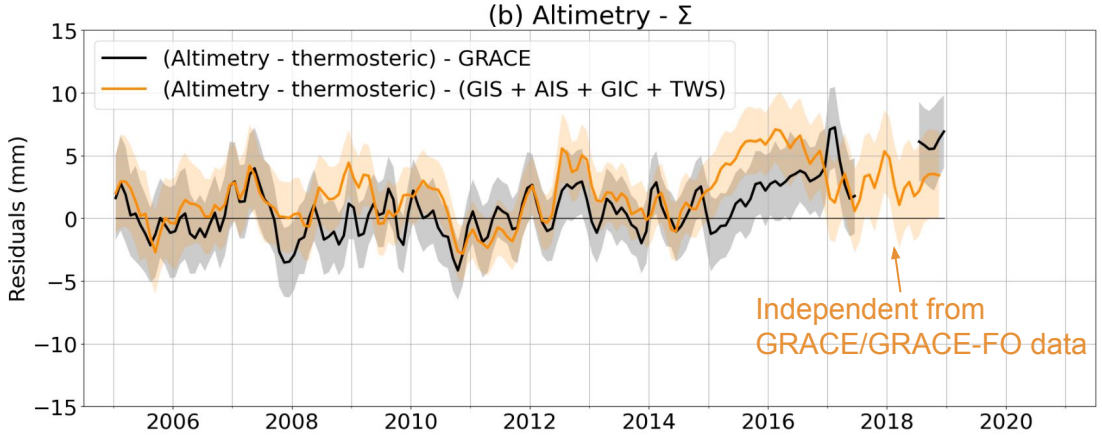
Budget residuals



- Residual trends over 2015-2018:
  - GRACE-(Alti. -thermo.)
    Trend = **-1.6 +/- 0.7 mm/yr**
  - GRACE-(GIS+AIS+GIC+TWS)
    Trend = **-1.6 +/- 0.4 mm/yr**

Budget residuals





- Residual trends over 2015-2018:
  - GRACE-(Alti. -thermo.)
    Trend = **-1.6 +/- 0.7 mm/yr**
  - GRACE-(GIS+AIS+GIC+TWS)
    Trend = **-1.6 +/- 0.4 mm/yr**
  - (Alti-thermo)-(GIS+AIS+GIC+TWS)
    Trend = **0.8 +/- 0.4 mm/yr**

➔ The remaining trend in the budget residuals may partly be due to the gravimetry-based global mean ocean mass.

➔ GRACE and GRACE-FO data cannot be fully responsible for the remaining residual trend.

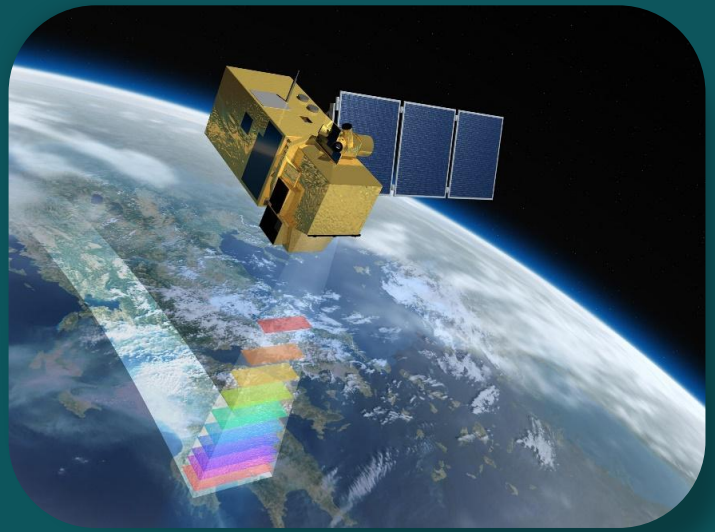
Conclusion

- The **non-closure** of the global mean sea level budget since **2015** is mainly due to:
  - a **salinity** drift (~40 % of the non-closure),
  - a drift in **Jason-3** radiometer wet tropospheric correction (~30 % of the non-closure). Improving Jason-3 drift correction would further reduce the non-closure.
- The remaining non-closure can be due to the other components. In particular:
  - part of it may be due to **GRACE and GRACE Follow-on** data,
  - large uncertainties are associated with **TWS from hydrological models**.

Reference: Barnoud, A., Pfeffer, J., Guérou, A., Frery, M.-L., Siméon, M., Cazenave, A., Chen, J., Llovel, W., Thierry, V., Legeais, J.-F. and Ablain, M. Contribution of altimetry and Argo to non-closure of the global mean sea level budget since 2016. *Geophysical Research Letters*, 2021. https://doi.org/10.1029/2021GL092824

Thank you for your attention.

anne.barnoud@magellium.fr



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