Wet troposphere correction derived from water vapour climate data records

Anne Barnoud[1], Bruno Picard[2], Benoît Meyssignac[3], Marie Bouih[1], Florence Marti[1], Michaël Ablain[1], Rémy Roca[3]

[1]Magellium, Ramonville-Saint-Agne, France; [2]Fluctus, Rabastens, France; [3]LEGOS, Université de Toulouse, CNES, CNRS, UPS, IRD, Toulouse, France

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Introduction

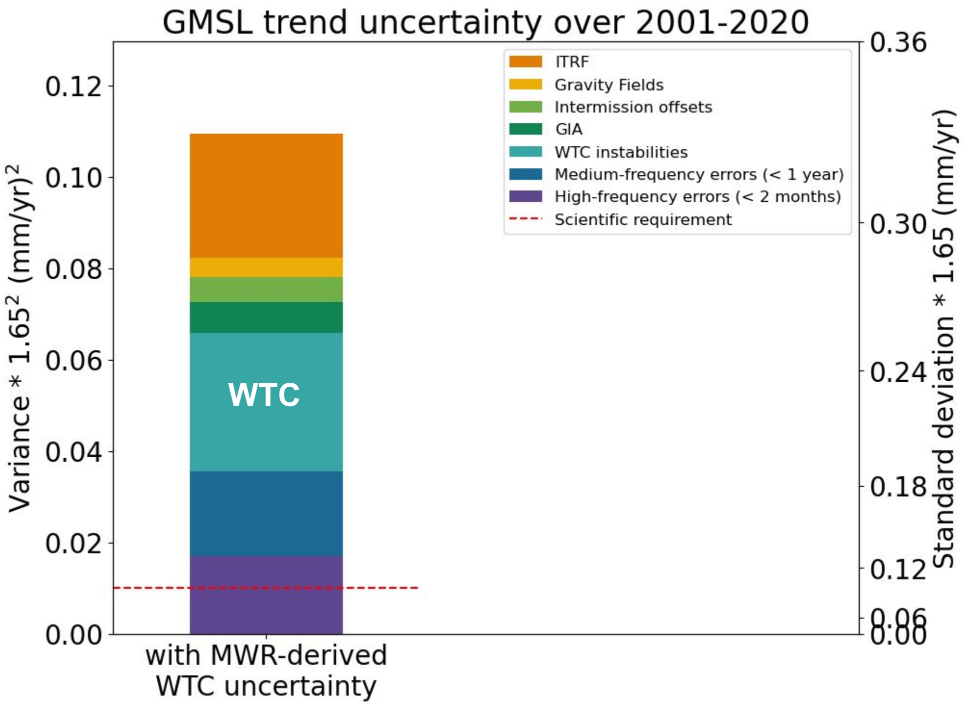
New **stability uncertainty requirements** have been established for **altimetry** to address scientific questions (Meyssignac et al., 2023) such as:

- closing the sea level budget and identifying the missing contributions;
- detecting and attributing the signal in sea level that is forced by greenhouse gases emissions;
- estimating the Earth's energy imbalance and constraining the Earth energy budget (see presentation by Michaël Ablain on Thursday).

	Current uncertainty over 20 years (Ablain et al., 2019; Guérou et al., 2023)	**Requirements at decadal time scales (Meyssignac et al., 2023)**
GMSL trend	0.3-0.5 mm/yr	< 0.1 mm/yr
GMSL acceleration	0.7-1.2 mm/yr/decade	< 0.5 mm/yr/decade

} 90 % confidence level, i.e. 1.65*standard uncertainty

Introduction



Major sources of uncertainties in the global mean sea level (GMSL) trend (Ablain et al., 2019; Guérou et al., 2023):

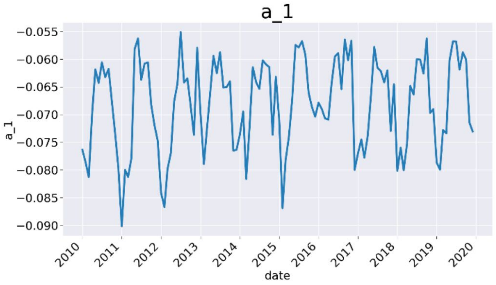
- high-frequency noise (< 1 year)
- ITRF in the precise orbit determination
- **wet troposphere correction** (WTC) computed from the microwave radiometer (MWR) onboard the altimetry missions

From water vapour to wet troposphere correction

Polynomial formula (Keihm et al., 2000; Stum et al., 2011)

$$WTC = (a_0 + a_1 TCWV + a_2 TCWV^2 + a_3 TCWV^3) TCWV$$

1. **Compute a_i coefficients and their uncertainties using ERA5 data**



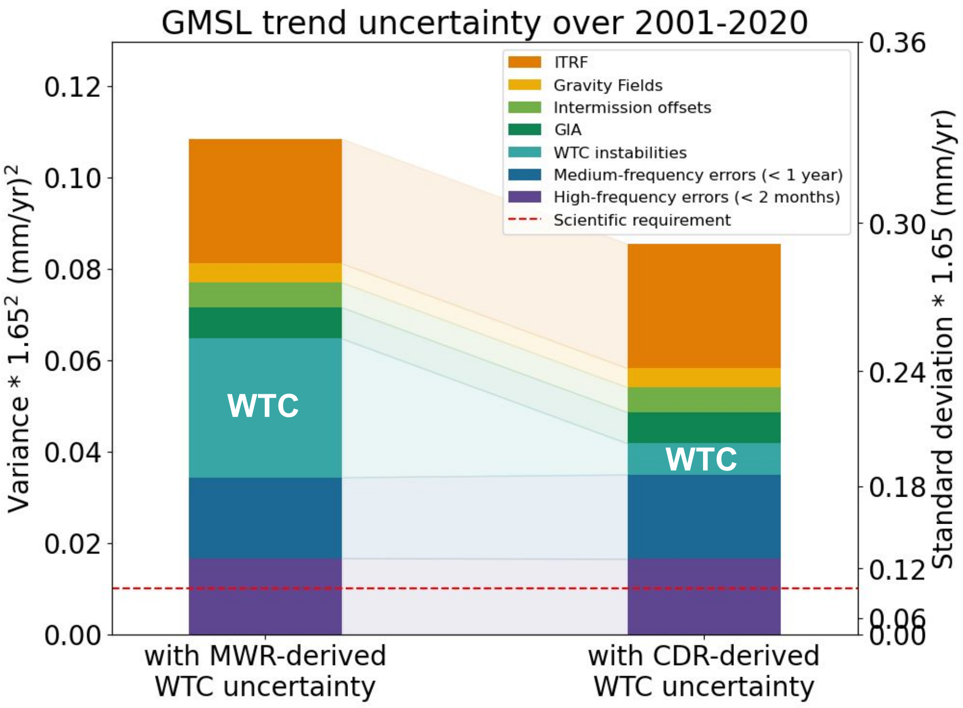
temporal average = a_i
standard deviation = σ_{ai}

Main assumptions
- the relationship is stable with time,
- the temperature has a negligible role.

2. **Compute WTC using climate data records (CDRs) of TCWV (REMSS and HOAPS)**, derived from brightness temperature measurements of SSM/I and SSMI/S satellite missions, that are **highly stable in time**, as shown by the GEWEX water vapour assessment (Schröder et al., 2016).

3. **Combine** MWR WTC high frequencies (< 1yr) with CDR WTC low frequencies (> 1yr) to avoid **potential** aliasing effects.

Introduction



For an overview of strategies to reduce other components, see poster CVL2023-007.

Water vapor climate data records can be used to improve the long-term estimates of the altimetry record:

1. by reducing the long-term uncertainty of the GMSL and derived climate variables such as the Earth's energy imbalance (see presentation at OSTST 2022, https://doi.org/10.24400/527896/a03-2022.3403)

➔ CDR-derived WTC trend uncertainty of **0.05 mm/yr** (68 % confidence level)

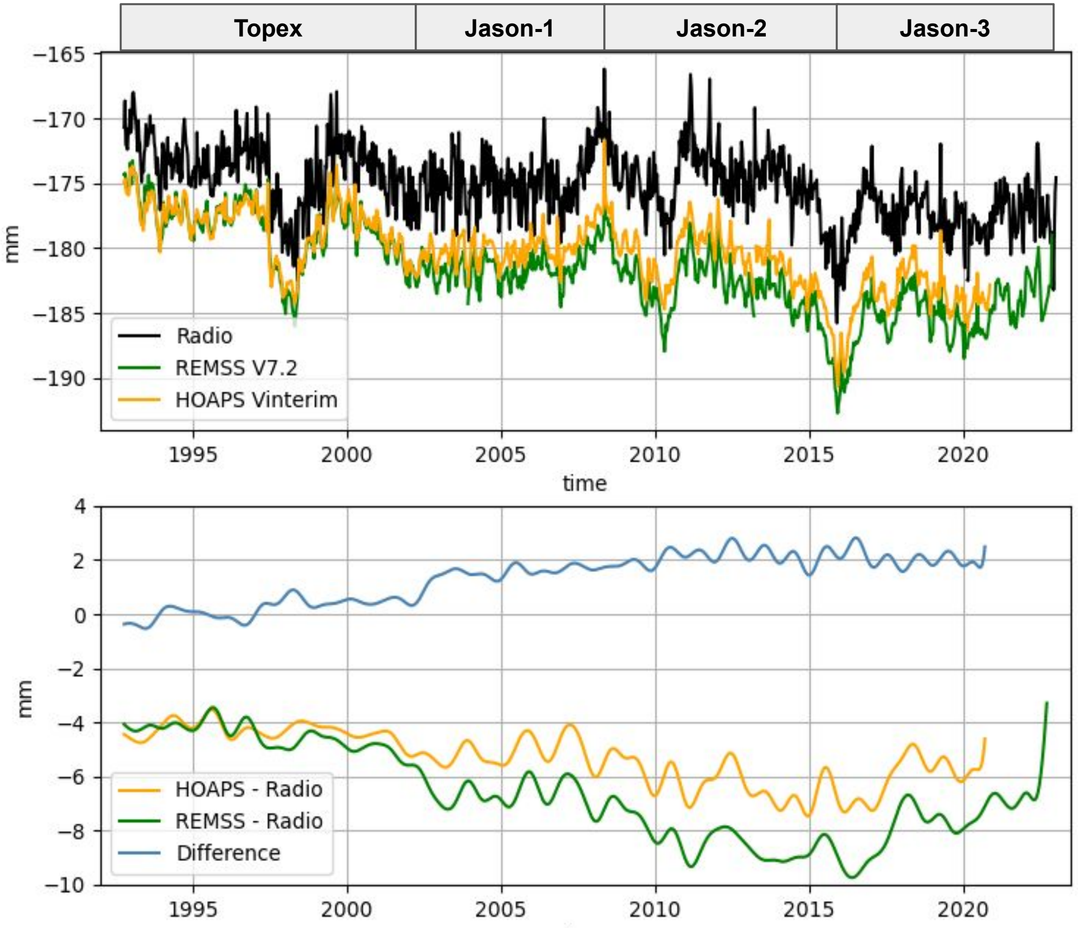
➔ GMSL trend uncertainty over 2001-2020 reduced by 12 % with respect to using the MWR-based WTC uncertainty

2. by validating the long-term stability of the WTC from the onboard MWR.

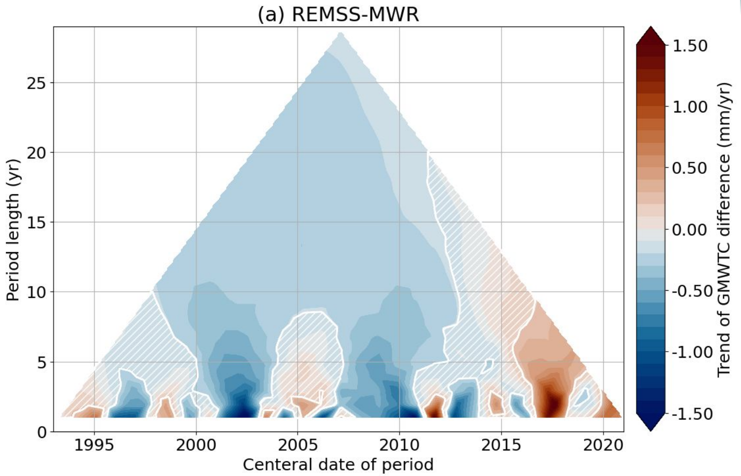
CDR-derived global mean WTC vs MWR-based WTC

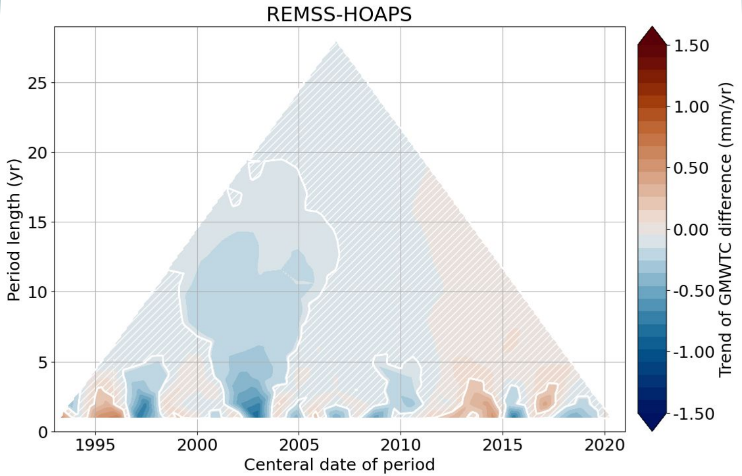
We use climate data **REMSS v7r2** and **HOAPS Vinterim (not official, precursor HOAPS V5 from EUMETSAT CM SAF)** CDR.

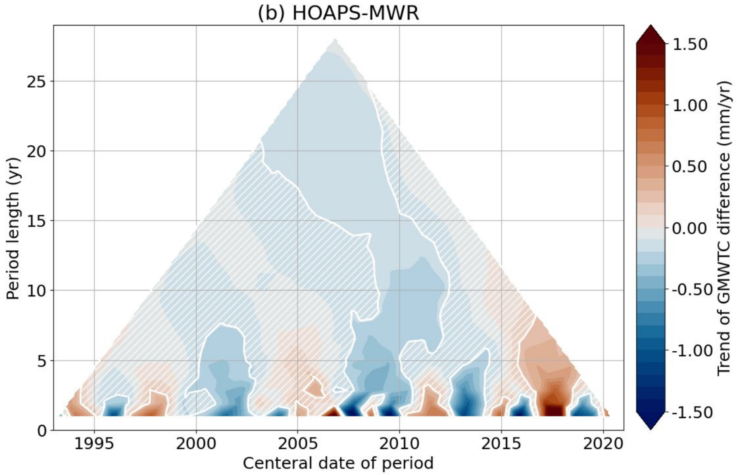
- The difference between CDRs and MWR shows a negative trend over the Jason-1 and Jason-2 periods.
- Over the Jason-3 period, a positive trend appear.



CDR-derived global mean WTC vs MWR-based WTC





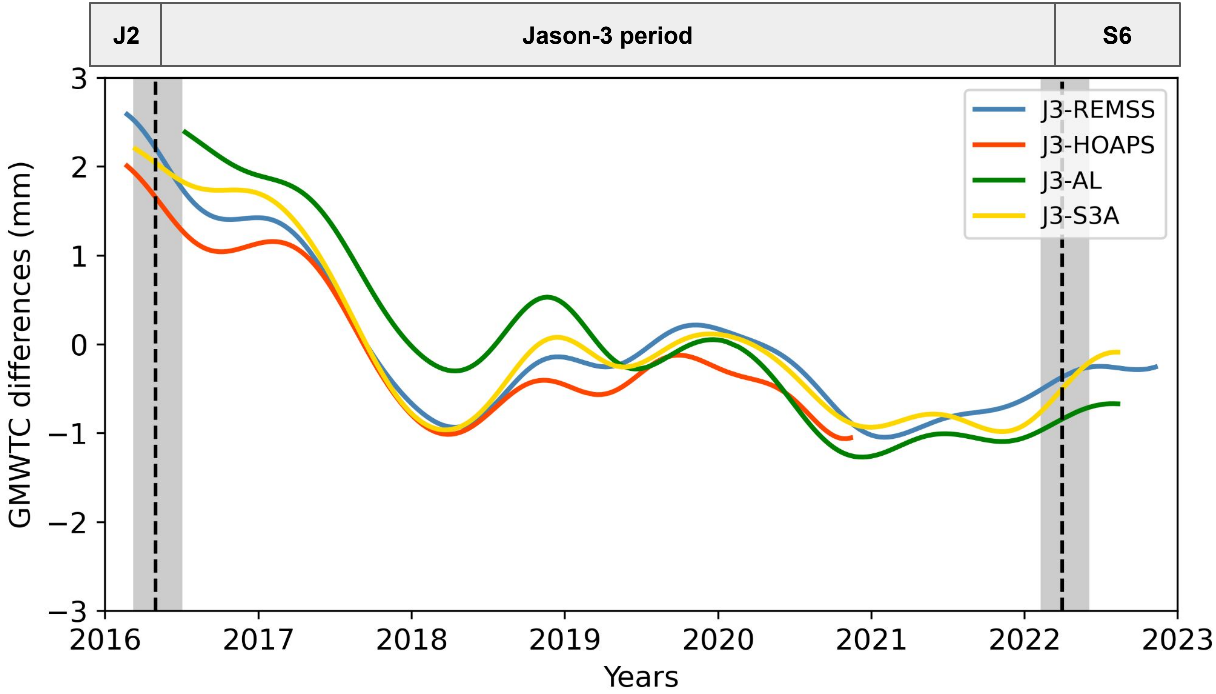


➔ REMSS and HOAPS derived WTC are usually consistent, except around 2002.

➔ REMSS and HOAPS “agree to disagree” with the MWR-based WTC around 2009-2010 and 2017-2018.

Assessment over Jason-3 period

Comparison between CDRs, Jason-3, SARAL/AltiKa and Sentinel-3A MWR WTC

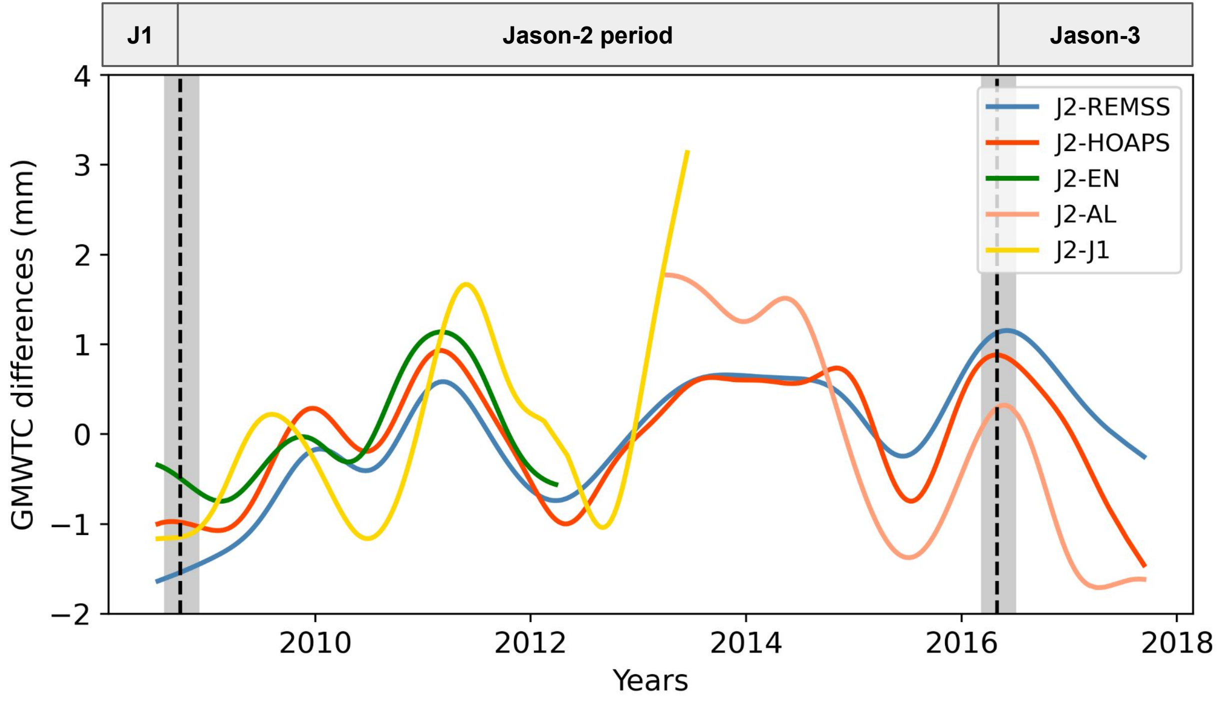


➔ Very good agreement between CDRs, SARAL/AltiKa and Sentinel-3A.

➔ All comparisons show a drift of Jason-3 MWR WTC at the beginning of the period: ~3 mm in less than 2 years.

Assessment over Jason-2 period

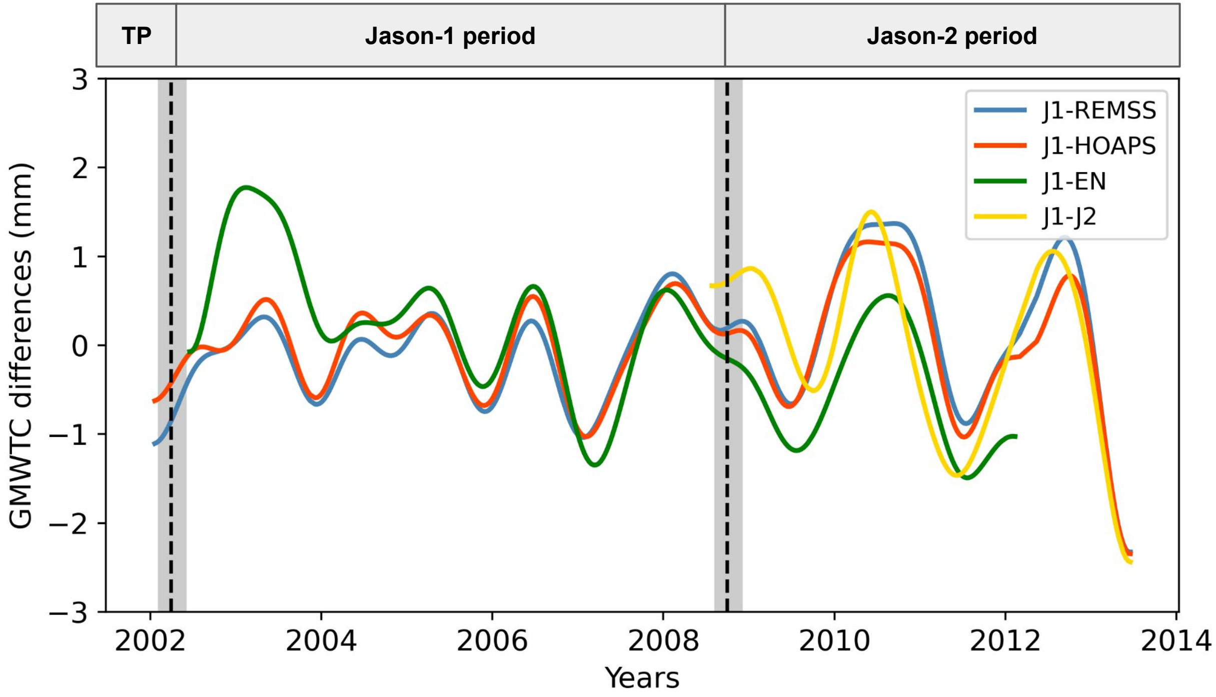
Comparison between CDRs, Jason-2, Envisat, SARAL/AltiKa and Jason-1 MWR WTC



- ➔ Good agreement between all WTC sources.
- ➔ Possible drift observed at the beginning of Jason-2 period: ~2 mm in 2 years.

Assessment over Jason-1 period

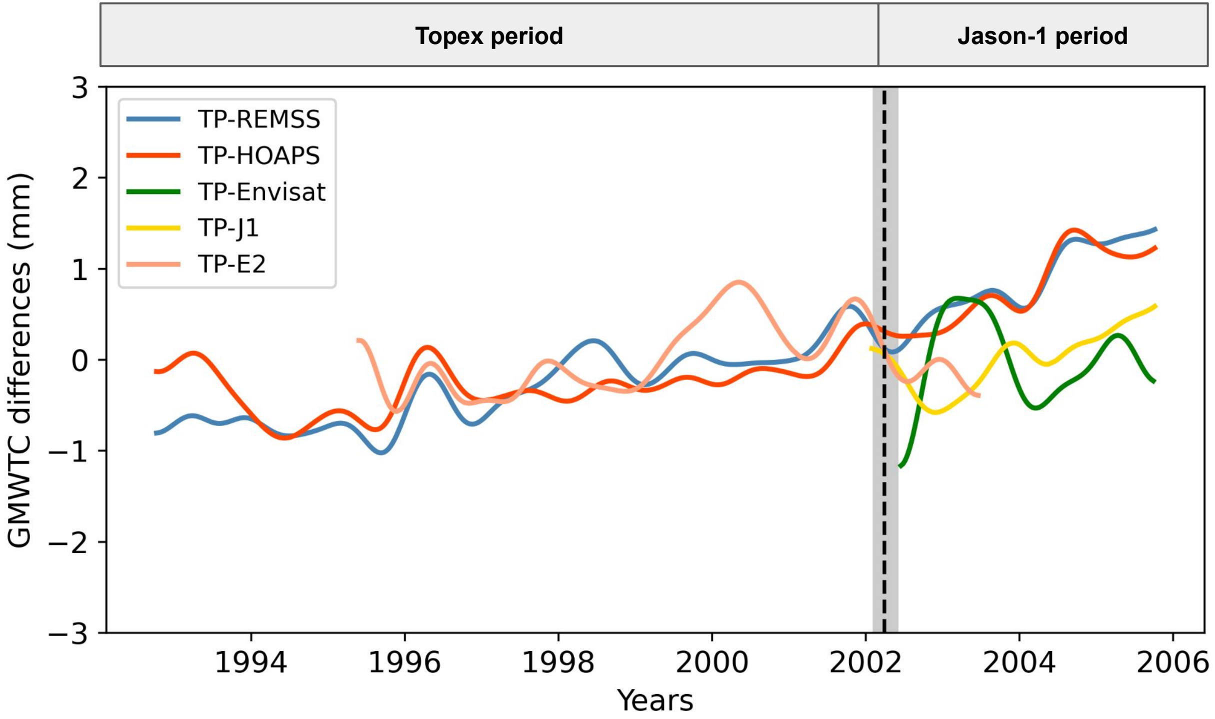
Comparison between CDRs, Jason-1, Envisat and Jason-2 MWR WTC



- ➔ Very good agreement between all WTC sources (except for the beginning of Envisat, which is expected).
- ➔ No particular drifts variations observed.

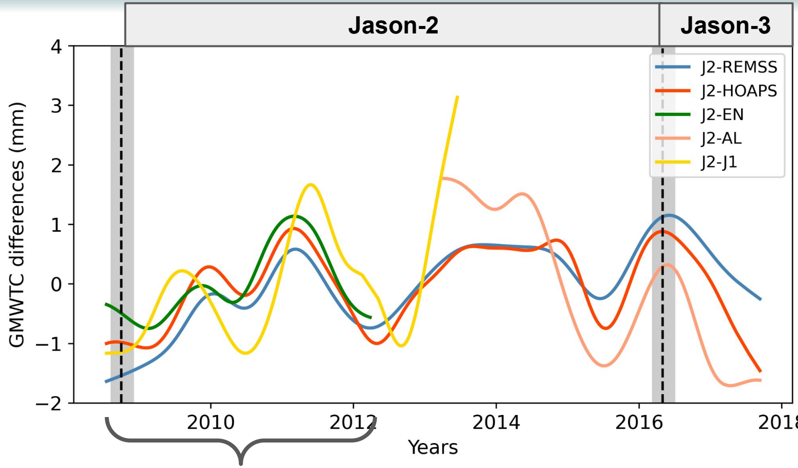
Assessment over TOPEX/Poseidon period

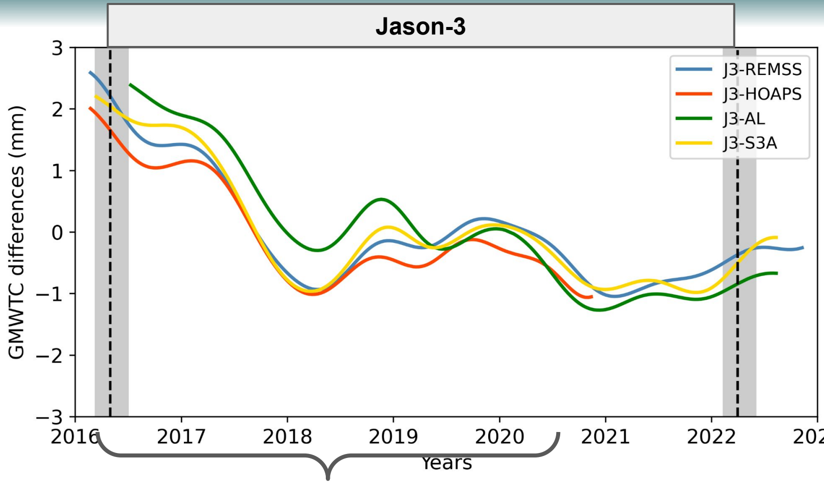
Comparison between CDRs, TOPEX/Poseidon MWR, Envisat, Jason-1 and ERS-2 MWR WTC



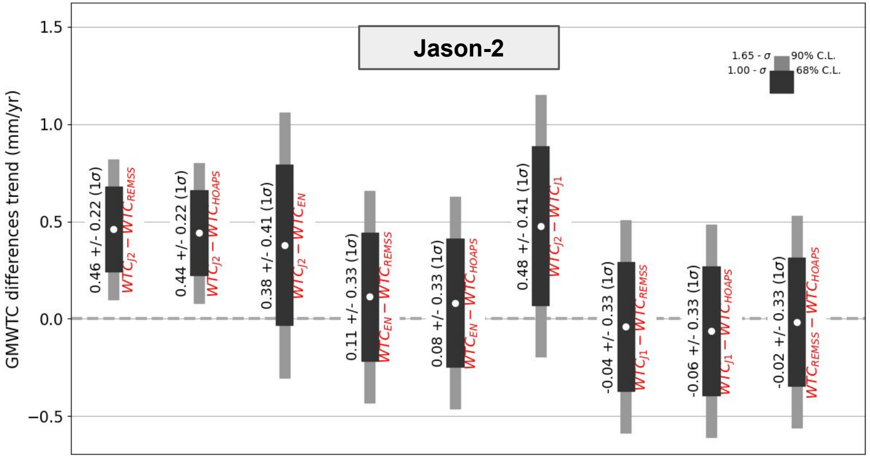
- ➔ CDRs are consistent with ERS-2 throughout the period where TOPEX is the reference mission.
- ➔ No particular variations observed except when TOPEX is no longer the reference mission.

Intercomparison trends

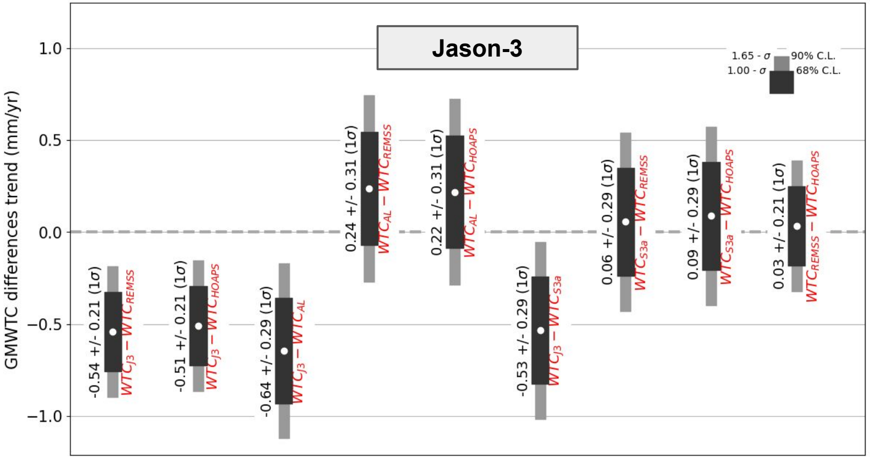




Period from 2008-07-16 to 2012-01-17



Period from 2016-02-22 to 2020-05-08



Conclusion

Conclusions

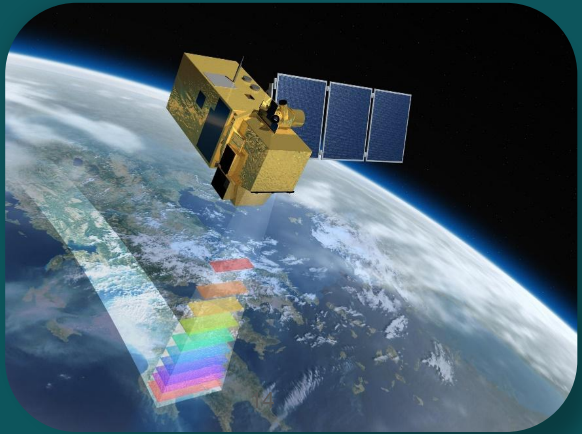
- HOAPS Vinterim and REMSS V7R2 water vapour climate data records show, in agreement with inter-mission comparisons:
    - a drift of **Jason-2** MWR WTC over 2009-2010 (~2 mm in 2 years),
    - a drift of **Jason-3** MWR WTC over 2016-2018 (~3 mm in less than 2 years).

Recommendations

- We recommend the use of water vapour climate data records for the **validation of the wet troposphere correction** of altimetry missions.
- This validation requires **regularly updated climate data records of water vapour**, with comprehensive uncertainty estimates described by **covariance matrices**.

The CDR-derived WTC is available on the AVISO+/ODATIS portal for independent assessment:
https://doi.org/10.24400/527896/a01-2022.018

Thank you for your attention.



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