Validation of the reprocessed TOPEX GDR-F products

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Motivation

Reprocessed TOPEX GDR-F product released Nov 7, 2023.

- TOPEX and POSEIDON data have both been reprocessed. Focus here on reprocessed TOPEX data.
- Numerical retracking used to improve altimeter parameters (Desjonquères, 2019) and self-consistent sea state bias (2D model from U. Colorado, 3D model from U. New Hampshire).
- End-of-mission radiometer calibration and coastal algorithms (Brown, 2009, 2010).
- Modern orbit solutions from GSFC and CNES.
- Current GDR-F geophysical model standards.

Prior official TOPEX (MGDR-B) product was reprocessed in 1996-1998.

- Based upon onboard estimates of range, SWH, and sigma0.
- Impacted by instrument degradation, especially on TOPEX Side-A altimeter, and radiometer drift.
- 1990s geophysical model standards now outdated.

How does the reprocessing impact TOPEX altimetry products?

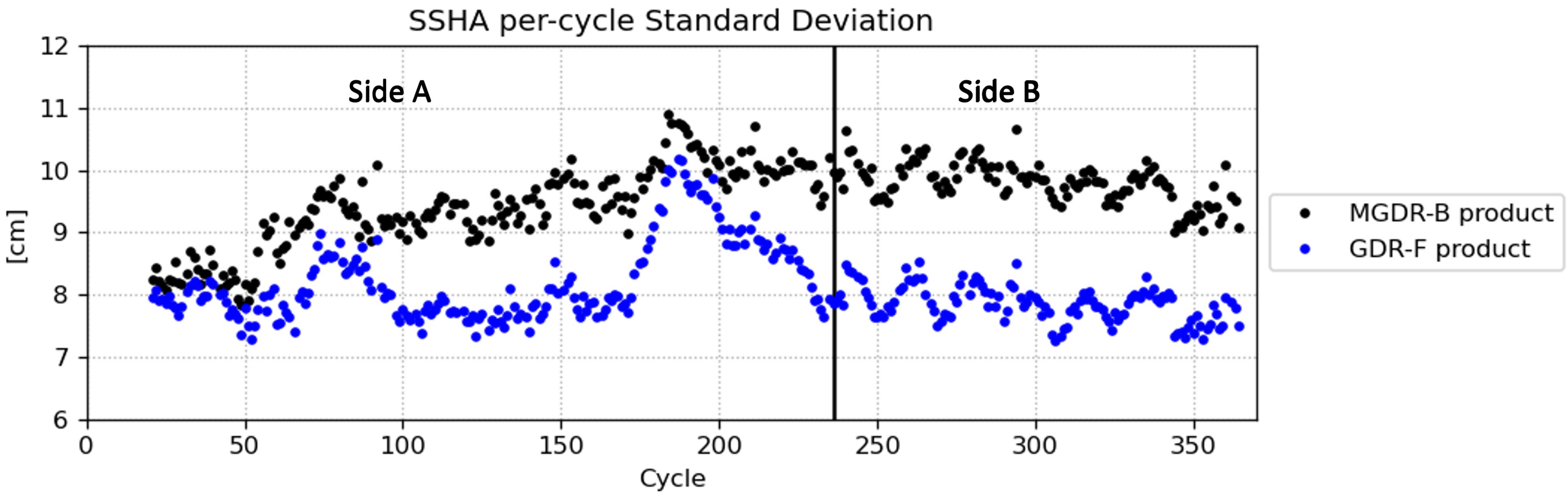
… in terms of

1. Performance of SSHA measurements

2. Consistency with successor Jason-1 mission

3. Long-term Trends

TOPEX SSHA performance – along-track

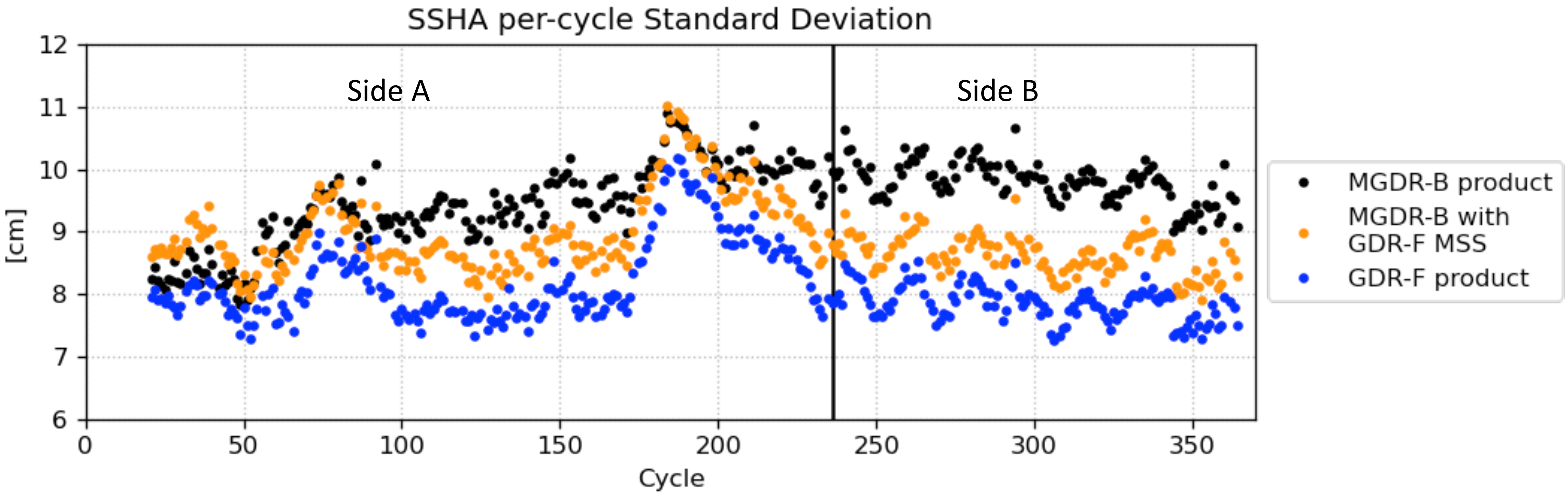


Reprocessing provides improved performance for SSHA across entire mission.
As observed by significantly lower standard deviation, up to about 1.5 cm for side B.

Performance
Consistency with Jason-1
Trends

TOPEX SSHA performance – along-track

Updated Mean Sea Surface is the largest contributor to improved along-track SSHA performance (up to about 1 cm std. reduction).



Modified SSHA by swapping out Mean Sea Surface from MGDR-B to GDR-F:

SSHA_modified = SSHA_MGDRB + MSS_MGDRB – MSS_GDRF

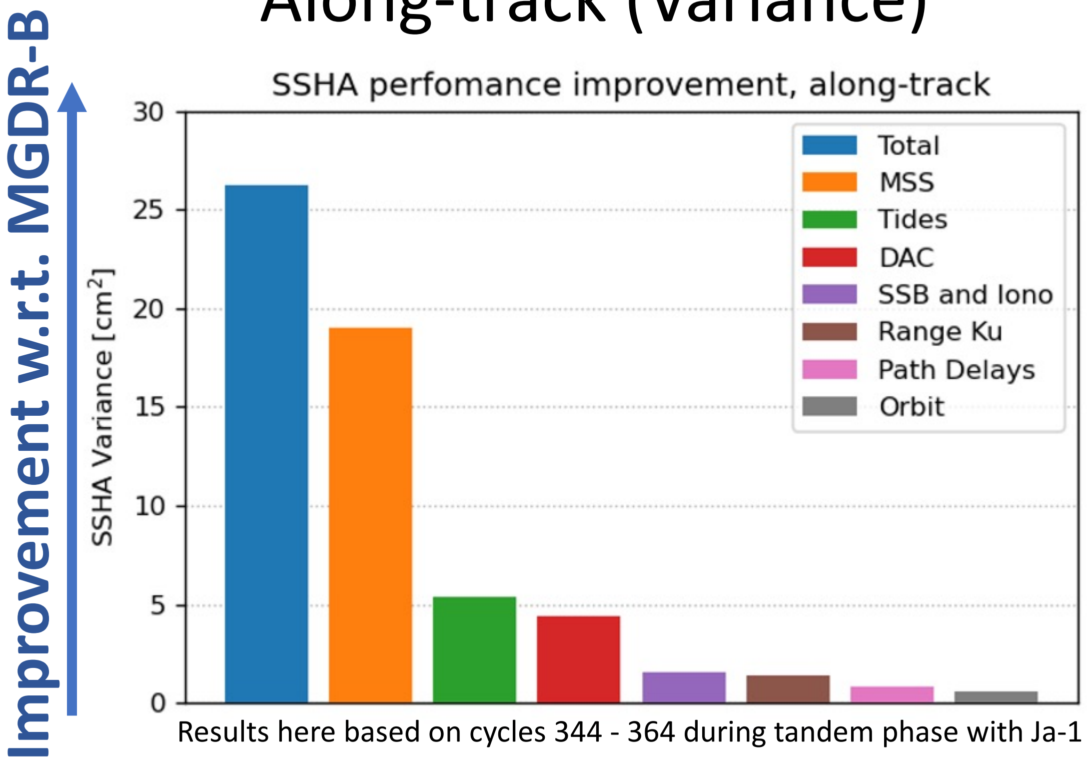
How does each component update influence the performance of the observed **along-track** SSHA?

- SSHA is computed from elements (represented here by groups).
- To assess the impact on performance, SSHA variance improvement is compared by swapping out one group at a time.

Parameter	MGDR-B	GDR-F
Orbit	Operational GSFC and CNES	GSFC (dpod2014v04)
Range correction	Wallops Cal1	Numerical Retracking
Mean Sea Surface	1990s standards	CNES/CLS 2015 and DTU18 (w.r.t. WGS84)
Ionospheric Corr.	Wallops Cal1 (from range)	Numerical Retracking (from range)
Sea State Bias	Parametric (Gaspar et al. 1994)	Non-Parametric 2-D and 3-D
IB and DAC	Only IB	ERA-Interim and Mog-2D from ERA-Interim
Model Dry and Wet Tropo. Corr.	ECMWF operational	ERA Interim
Ocean Tides	1990s standards	FES2014b
Solid Earth Tide	1990s standards	No change
Internal Tide	1990s standards	Zaron (2019)
Pole Tide	1990s standards	Desai et al. (2015), Ries and Desai, 2017

How does each component update influence the performance of the observed **along-track** SSHA?

Along-track (Variance)



Results here based on cycles 344 - 364 during tandem phase with Ja-1

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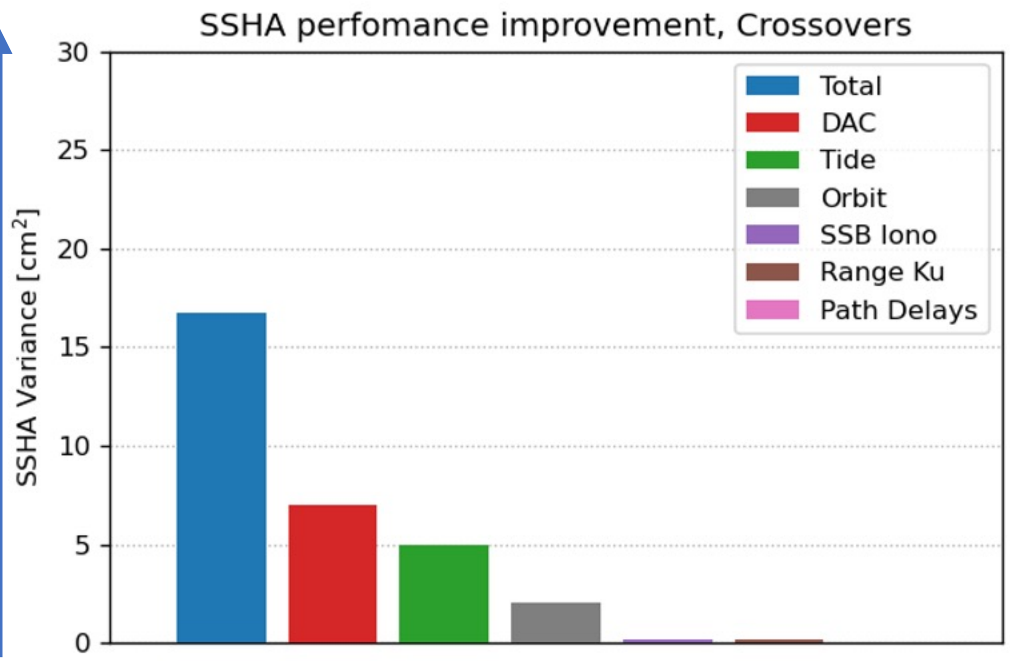
- **As expected, modern geophysical models provided most significant improvements.**
- **In addition, altimeter parameters from numerical retracking (range, SSB, and Ionospheric correction) contribute to performance improvement.**

How does each component update influence the performance of the observed SSHA **crossovers**?

Crossovers (Variance)

Improvement w.r.t. MGDR-B



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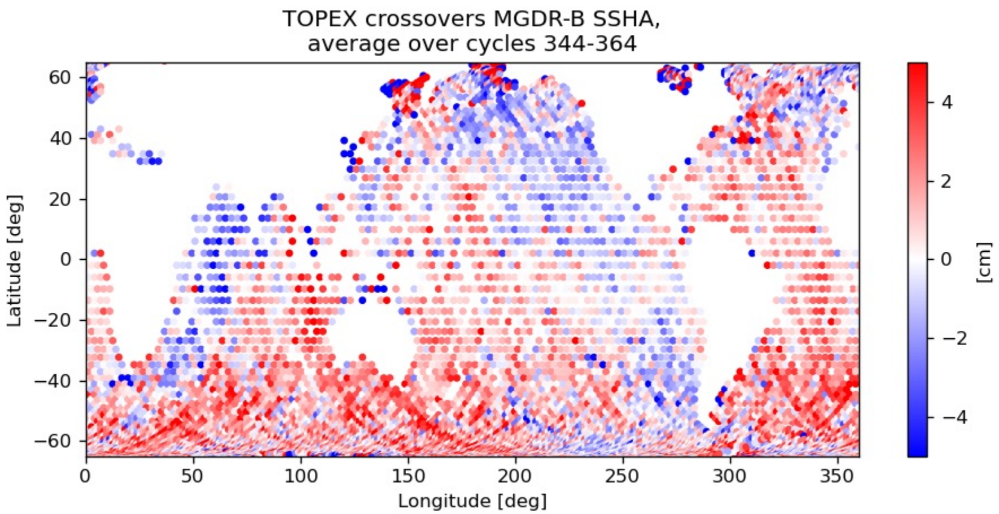
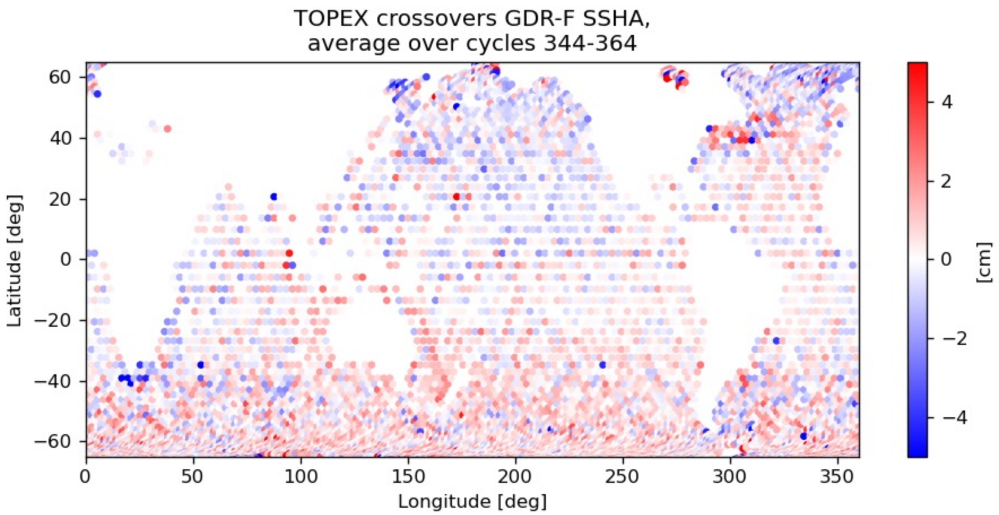
- **As expected, modern geophysical models provided most significant improvements.**
- **In addition, altimeter parameters from numerical retracking (range, SSB, and Ionospheric correction) contribute to performance improvement – with a smaller effect for crossovers compared to along-track performance.**

How do SSHA components impact geographical patterns?

MGDR-B



GDR-F

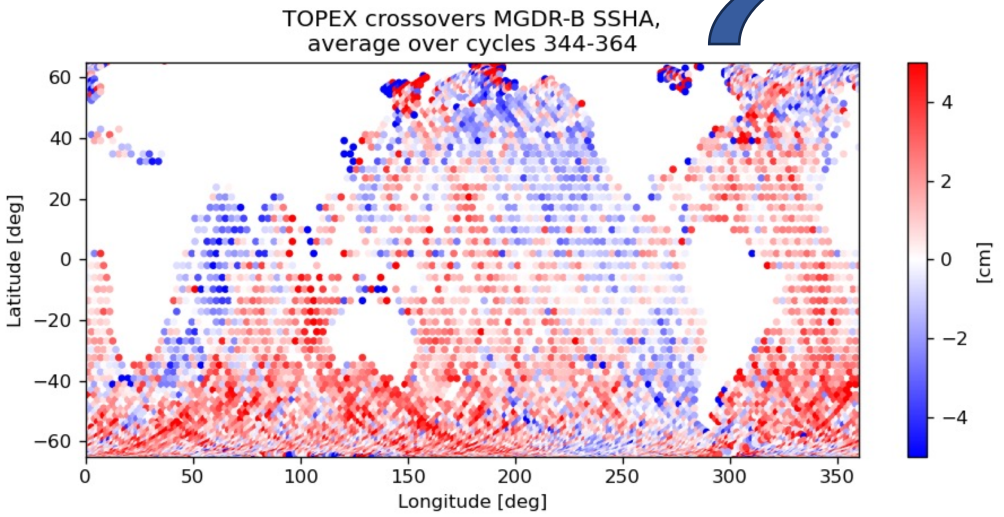


Average of SSHA differences at crossover points allow investigating geographical patterns

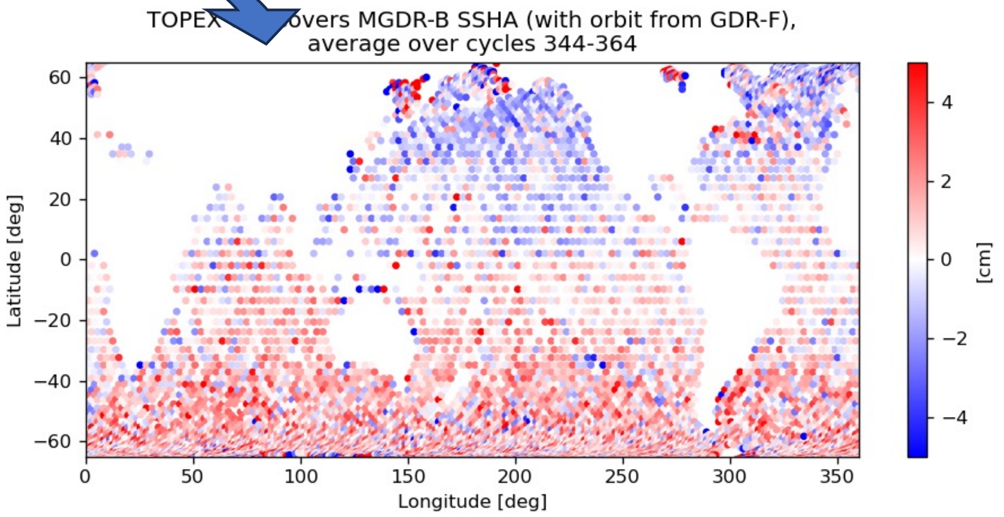
Strong reduction of the geographical discrepancies between ascending and descending passes.

GDR-F Orbit significantly reduces geographical patterns

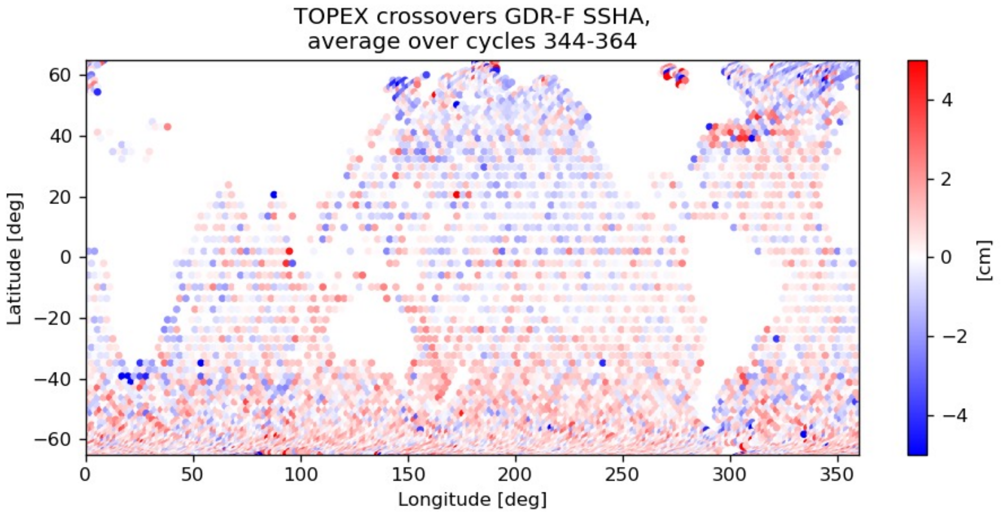
MGDR-B



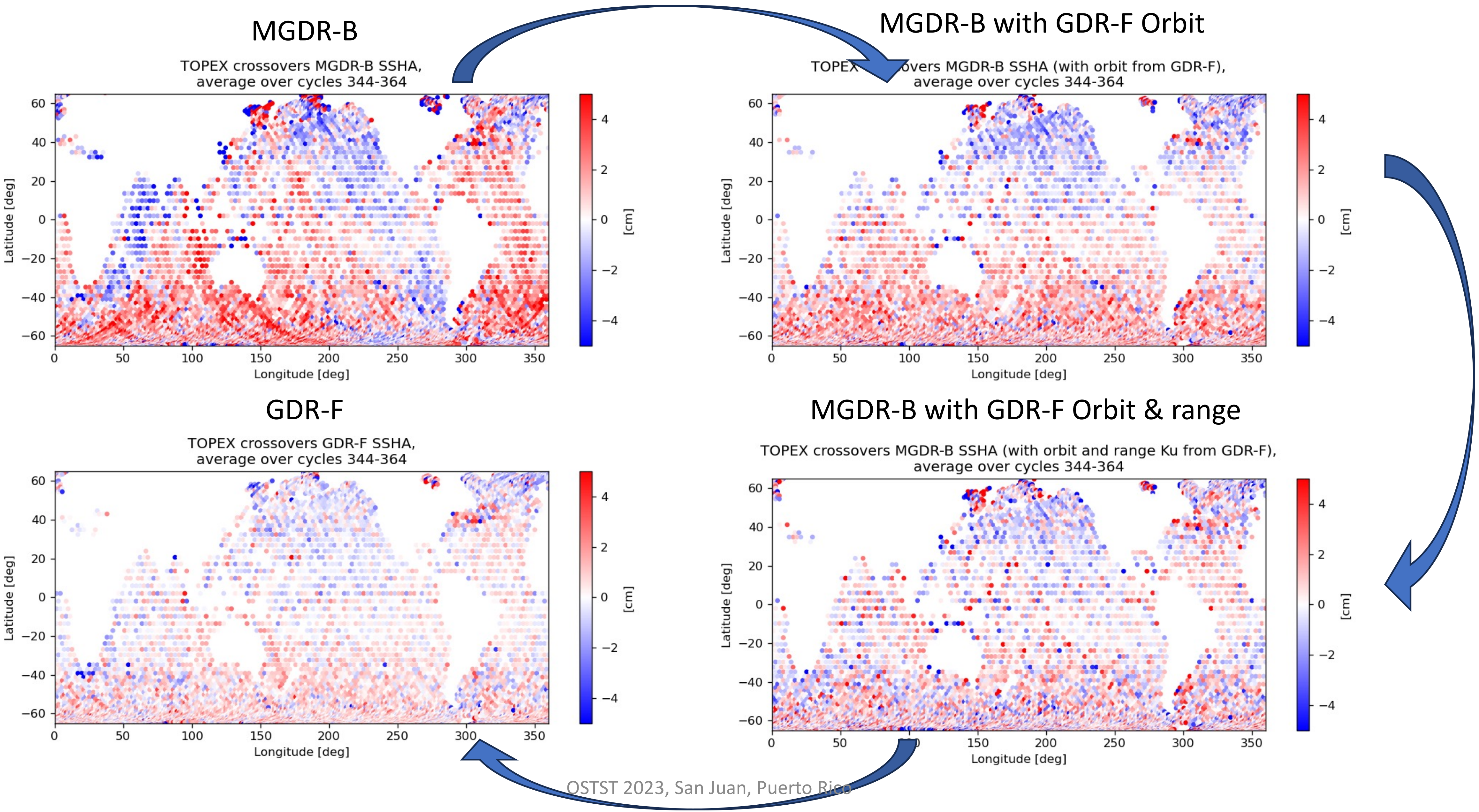
MGDR-B with GDR-F Orbit



GDR-F



Numerical retracking reduces hemispheric biases



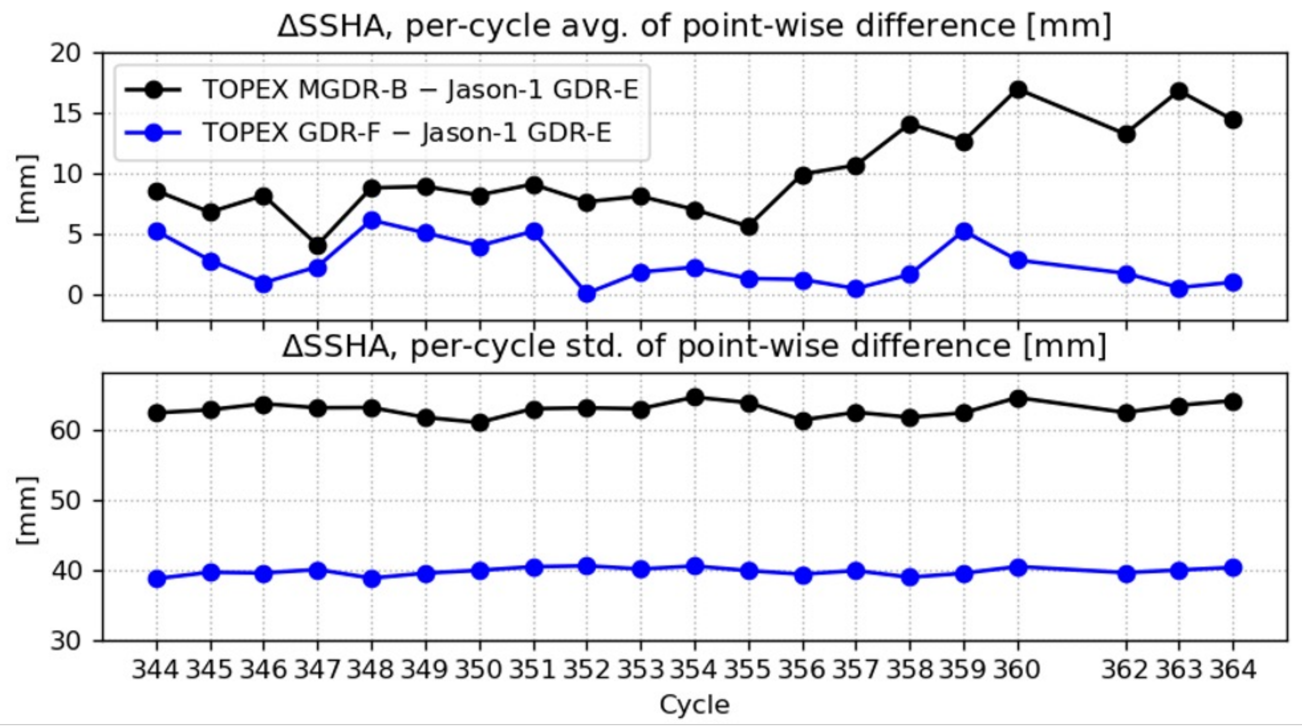
Performance

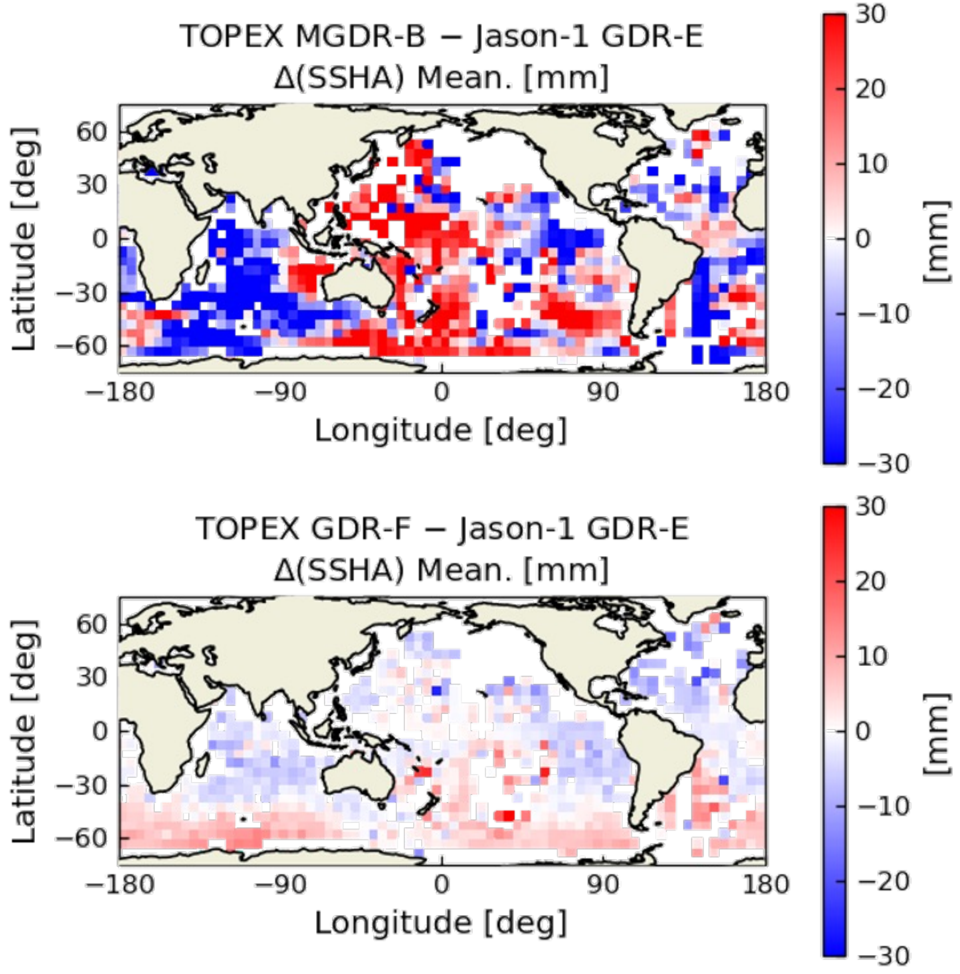
Consistency with Jason-1

Trends

Consistency with successor mission Jason-1

Sea Surface Height Anomaly



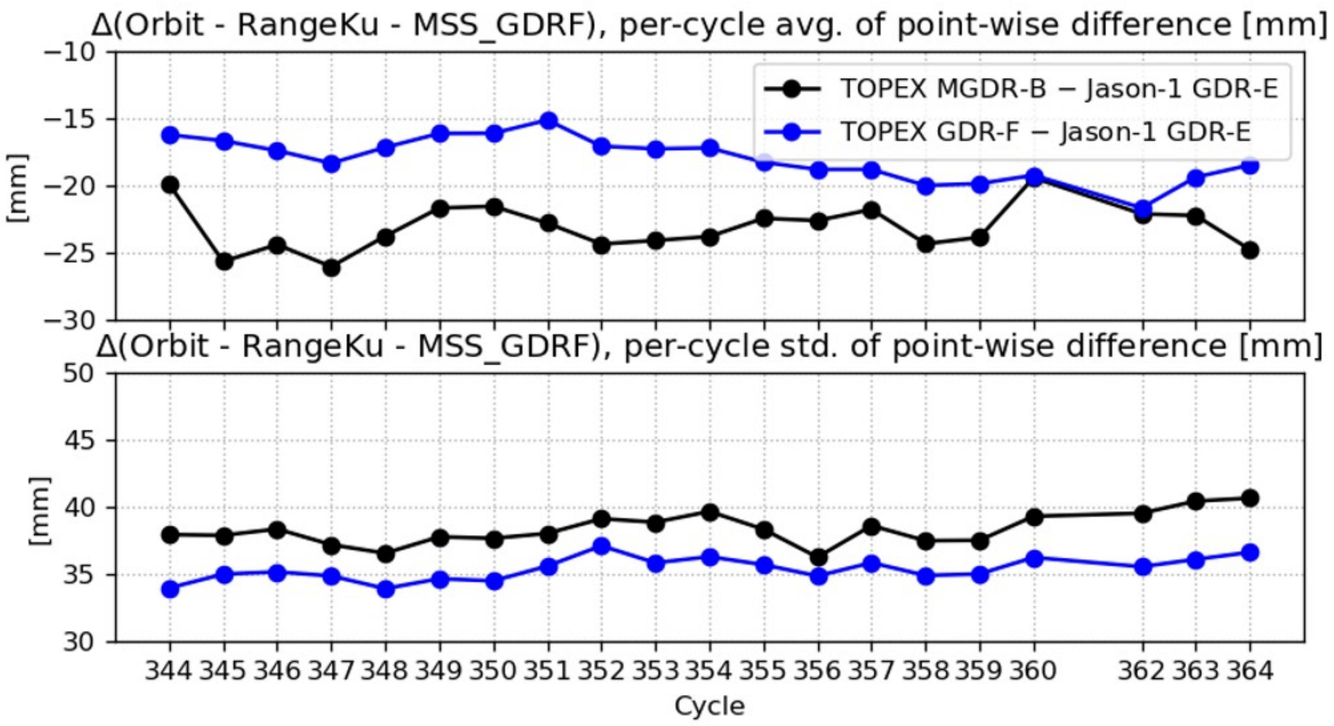


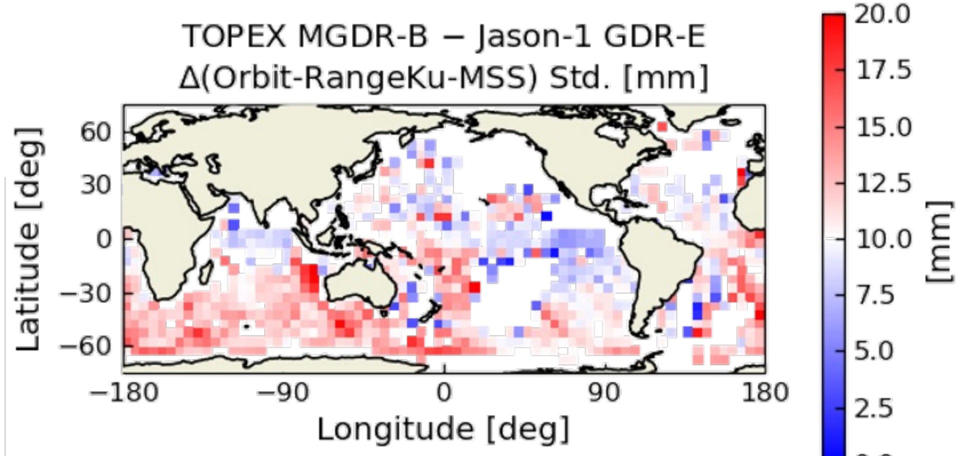
- **Significantly improved consistency with Jason-1**
- **Now reflecting expected noise within each system (e.g., 40/(sqrt(2)) = 28 mm)**

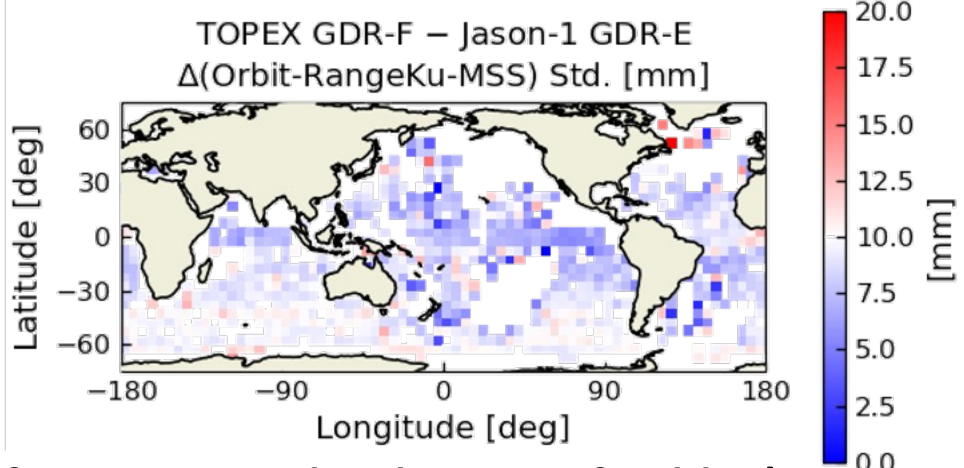
Consistency with successor mission Jason-1

Orbit – Range (Ku) – Mean Sea Surface

Applying GDR-F MSS to MGDR-B.





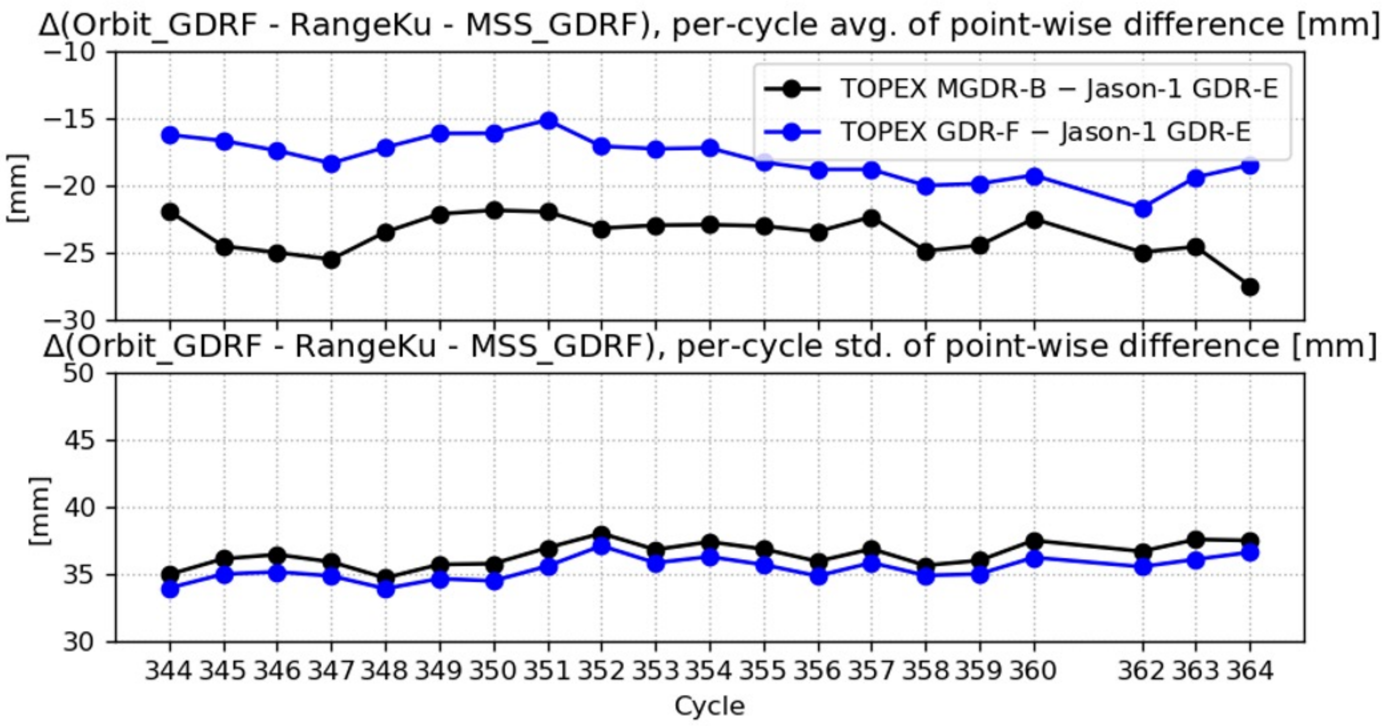


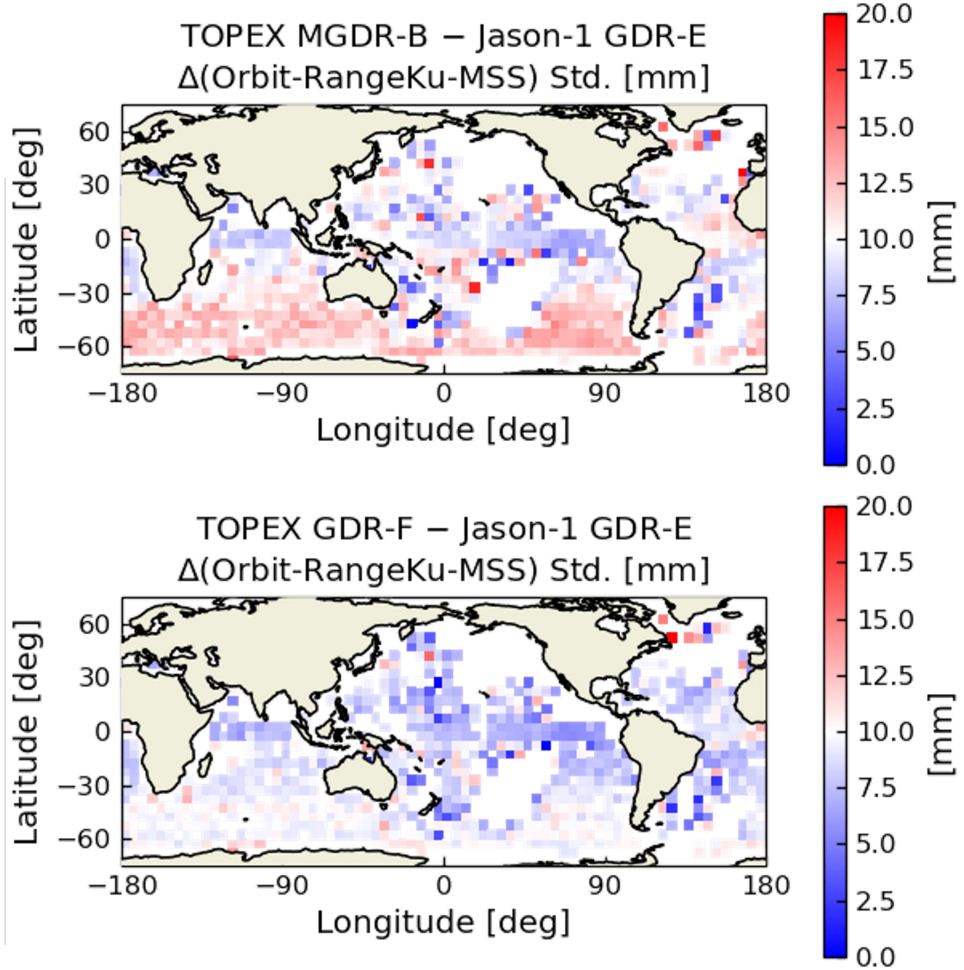
Improved orbit solution is improving the consistency (stability of averages and reduction of stddev) of the difference.

Consistency with successor mission Jason-1

Orbit – Range (Ku) – Mean Sea Surface

Applying GDR-F MSS and orbit to MGDR-B.

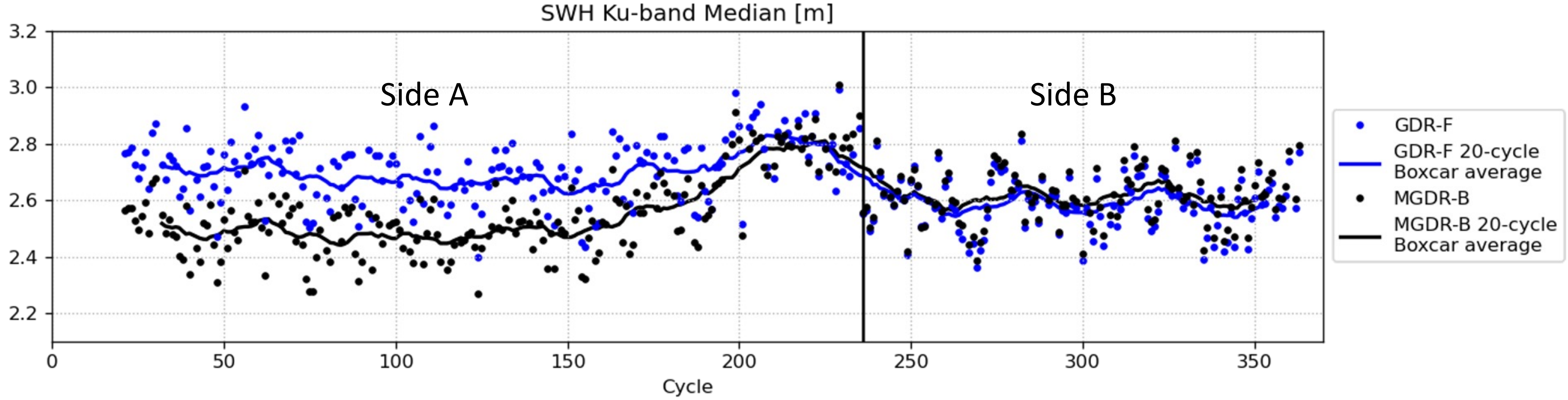




Numerical Retracking improves consistency with Jason-1

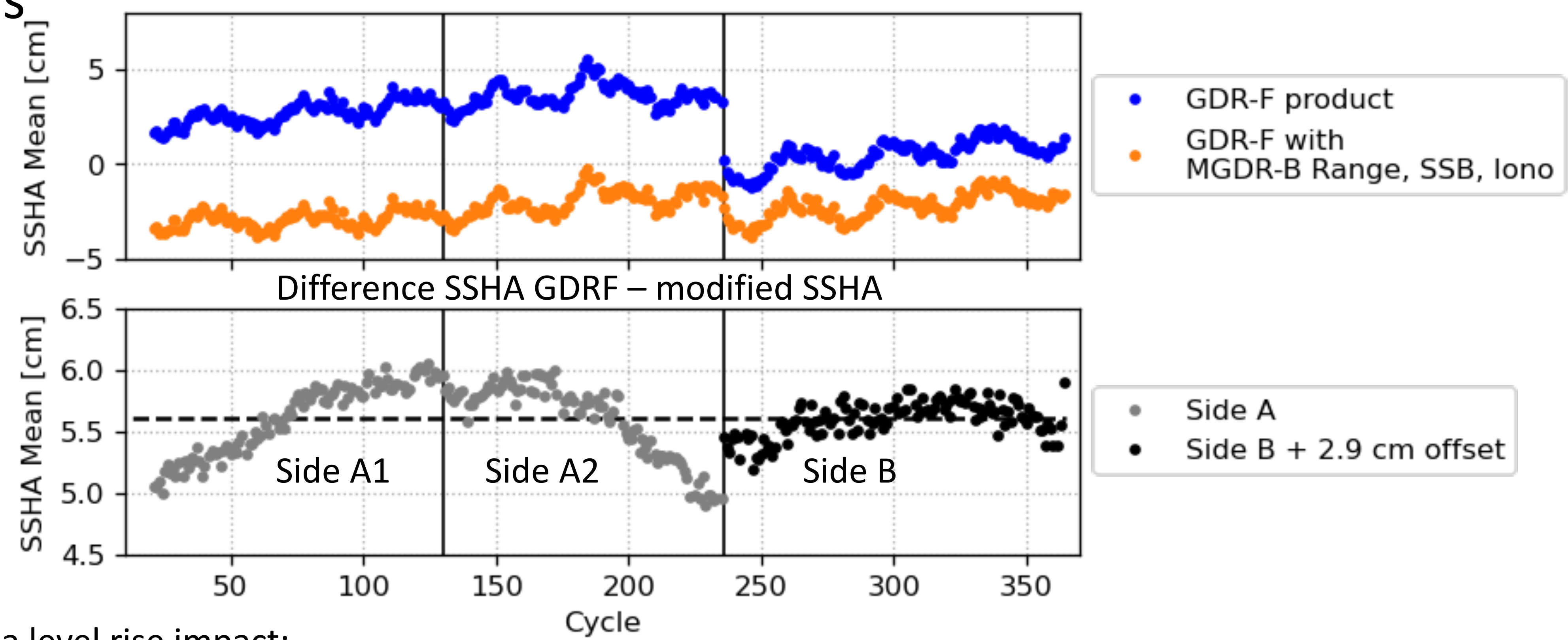
Significant Wave Height timeseries

Numerical retracking improves stability of SWH for overall mission (GDR-F SWH increase up to about 0.2 m for side A).



TOPEX SSHA Time Series

Updated Range, SSB, Ionospheric correction improve consistency in long-term trends



For discussion on sea level rise impact:

- **Brian Beckley** et al.: Assessment of Reprocessed TOPEX/Jason/Sentinel-6 Altimetry: Impact on Global Mean Sea Level Estimates (poster CVL2023_008)
- **Victor Quet** et al.: Estimation of the Topex A/B bias and associated uncertainty - A multi methods approach (talk)

Conclusions

The reprocessed TOPEX altimetry products show…

Improved performance of SSHA estimation

- **Updated geophysical models and orbit solution**: provide the largest improvement in SSHA performance.
- **Numerical retracking improves side-A range and SWH stability and mitigates** hemispherical errors in both side-A and side-B and improves along-track performance.

Improved consistency with successor mission Jason-1

Overall better **agreement in terms of geographical correlation** and significantly **improved stability** between TOPEX GDR-F and Jason-1 GDR-E.

Improved consistency of long-term trends.