Regional and Global CAL/VAL for Assembling a Climate Data Record

Summary

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Some Highlights from the Oral and Poster Sessions (regional studies)

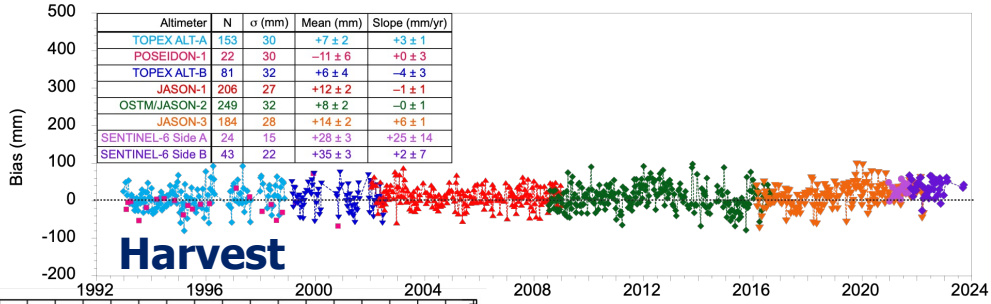
- Historical cal/val sites continue to support in-situ cal/val of reference missions from diverse locations, approaches, and in-situ instruments. Results show centimeter level consistency for all missions (see next slides)
- The Harvest Experiment: New Beginnings *(Haines et al.)*
  - The Harvest Experiment is well positioned to move forward seamlessly, without the platform itself
  - Calibration metrics from GPS buoys are competitive with those from platform, except under high wave conditions (see Wu et al. poster for details).
  - Preliminary results from Vandenberg tide gauge show promise of this new sensor. Stable land at Vandenberg is an advantage compared to the platform.
  - Coupled with assets on Catalina (e.g., Transponder, see Desjonqueres et al. poster for details), Harvest will continue to provide insights on current and future altimetric systems.
- Jason-3 & Sentinel-6 MF calibration at the Corsica facilities *(Bonnefond et al.)*
  - Sentinel-6 MF: No major changes from F06 to F08 (except the addition of Numerical Retracking). Numerical retracking (NR) shows a small improvement in terms of SSH bias standard deviation. SSH bias lower by 3.7mm for NR compared to MLE4: NR provide a better agreement with Jason-3
  - Evolution of the Corsica facilities (up to SWOT swath), See “Extending the Corsica facilities up to SWOT swath” poster for details
    - Validation using all overflying satellites over a 13yr period shows a good consistency (12.6 mm rms)
    - Very promising results when used for SWOT nadir SSH bias (and also for KaRIn)
- High resolution in situ sampling in Bass Strait and surrounds: Early perspectives on validation of SWOT Fast Sampling Phase data *(Watson et al.)*
  - GNSS buoy array in Bass Strait is providing useful insight into SWOT over the Fast Sampling Phase (1-day orbit). Useful tool to probe intra swath variability and validity of corrections.
  - Complementary results on Jason-3 and Sentinel-6 MF were given in the presentation during the Sentinel-6 Validation Team (S6VT) Meeting (“Updated S6MF validation results from the Bass Strait validation facility, Australia” from *Watson et al.*)
- Crete ESA Permanent Facility for Altimetry Calibration *(Mertikas et al.)*
  - Transponder & Sea-Surface Ground infrastructure
  - Diverse Instrumentation, Settings & Processing
  - Uncertainty Budget in FRM Standards
  - See also the poster for details on “Absolute Calibration of the Chinese HY-2B Altimetric Mission” (*Mertikas et al.*)

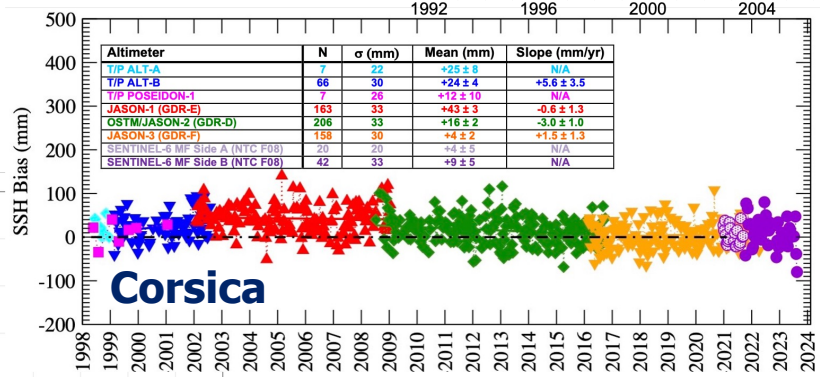
Current Results from Dedicated Calibration Sites

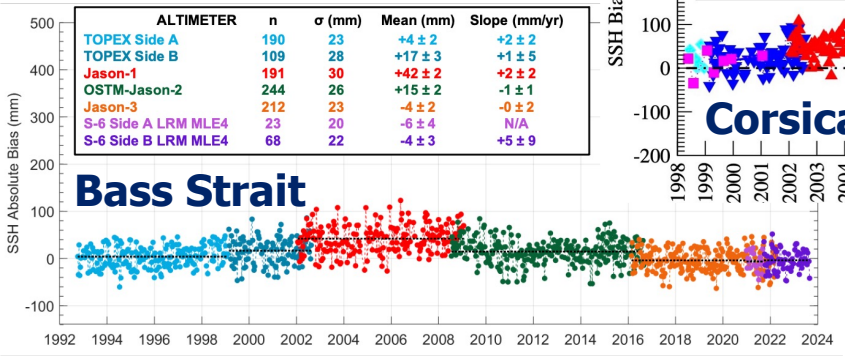
All missions/sites time series from Absolute SSH Bias Estimates

(Bonnefond et al., [Corsica], Haines et al. [Harvest], Watson et al. [Bass Strait])

Historical cal/val sites continue to support in-situ cal/val of reference missions from diverse locations, approaches, and in-situ instruments. Results show centimeter level consistency for all missions



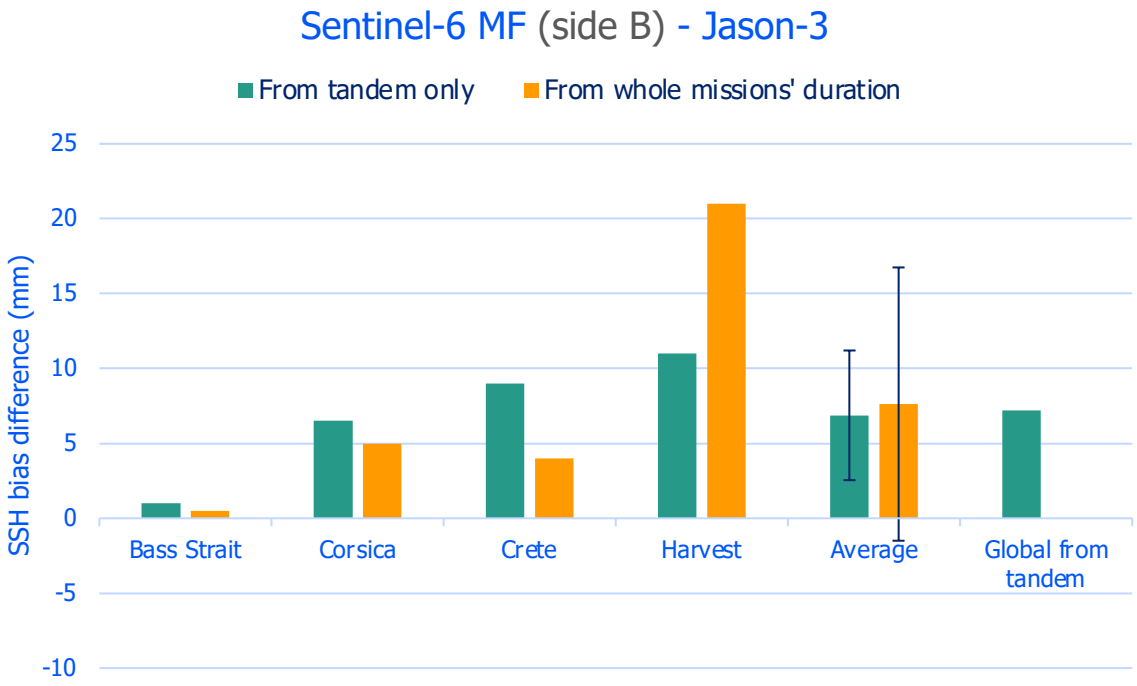




Current Results from Dedicated Calibration Sites (con't)

Intermission bias from Absolute SSH Bias Estimates difference

(Bonnefond et al., [Corsica], Haines et al. [Harvest], Mertikas et al. [Gavdos], Watson et al. [Bass Strait])



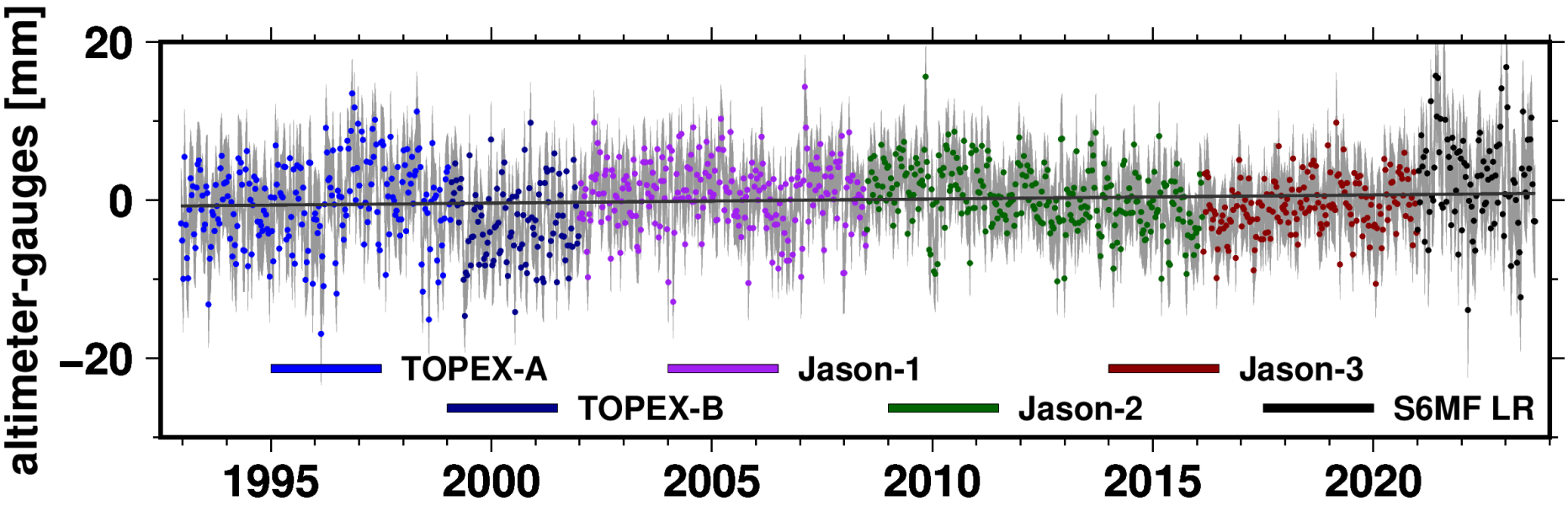
- **Very consistent results from all sites at the few mm level during the tandem phase with an average of +6.9 mm very close to global determination (+7.2 mm)**
- **Also from the whole missions' duration except from Harvest that exhibits a recent uptick (since 2018, needs further investigations)**

Some Highlights from the Oral and Poster Sessions (regional studies)

- Using corner reflectors for altimetry calibration: Joint presentation (*Ferran et al. and Maraldi et al., see respective posters for details*)
  - Corner reflectors (CR) have demonstrated to be accurate tools for radar altimeter monitoring: Performance equivalent to active transponders
  - High stability of the estimations, even for sigma0
  - Not band-dependent: CR seen on SWOT swath: Corner reflectors are a very valuable means but does not replace the active transponder systems
  - The site selection is critical for corner reflector success
- Tide gauge comparisons for Jason-3, Sentinel-3, and Sentinel-6 MF*(Leuliette et al.)*
  - Jason-3: Verified JPL AMR path delay correction
  - Sentinel-6 MF: No significant drifts in LR Numerical Retracker: The higher variance of NR near the gauges presents a challenge for validation of the stability requirement
  - Sentinel-3: No significant drifts; Sentinel-3A SAR drift (BC005) reduced from BC004
  - 30-year reference mission/tide gauge comparison (see next slide)
  - See also poster for long term sea level data from tide gauges over all around the world: “Linking the Permanent Service for Mean Sea Level’s (PSMSL) global mean sea level dataset to the ellipsoid” (*Matthews et al*.)

30-year reference mission/tide gauge comparison (Leuliette et al.)

The residuals from the 30-year reference series record are consistent with no drift (0.05 ± 0.8 mm/year, 95% CI)



Some Highlights from the Oral and Poster Sessions (regional studies)

- Towards validation of SWOT in the coastal zone: a radar altimetry and water level gauge case study in the Bristol Channel and Severn River-Estuary system (Lichtman et al.)
  - The L3 product is merged from the KaRIn swath and nadir altimeter data, with a resolution of 2 km. To make the data comparable to the Water Level Gauges (WLG), and the Cryosat 2 and Sentinel 3 analysis.
  - Compared to the Cryosat 2 and Sentinel 3 analysis, the SWOT data are of similar quality with slope close 1:1 and RMSE 0.2 – 0.4 m with the noiseless data showing the improvement of removing data close to the shore.
- PATASWOT: a Cal/Val experiment in the Argentine Patagonian Continental Shelf during the 1-day repeat orbit of SWOT *(Saraceno et al.)*
  - Two moorings were deployed in the Argentine Continental Shelf under the SWOT 1-day-repeat track, they were equipped with Conductivity, Temperature and Depth (CTD) recorders and an upper-looking current meter
  - Preliminary results:
    - AVISO gridded and along track data patterns do not correspond with observations from SWOT
    - Hovmöller diagrams suggest the propagation of a signal of about 1 m/s towards the south ?

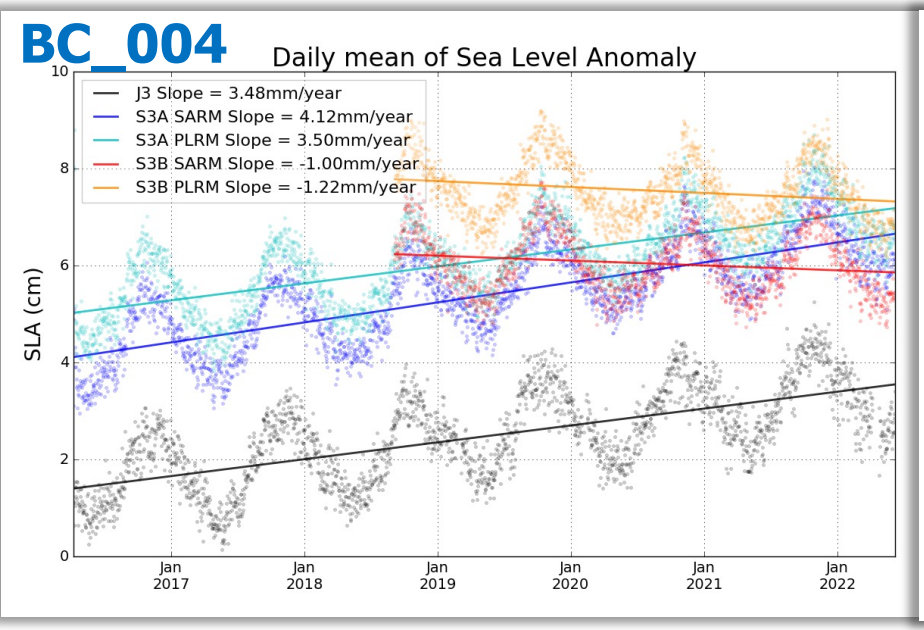
Some Highlights from the Oral and Poster Sessions (global studies)

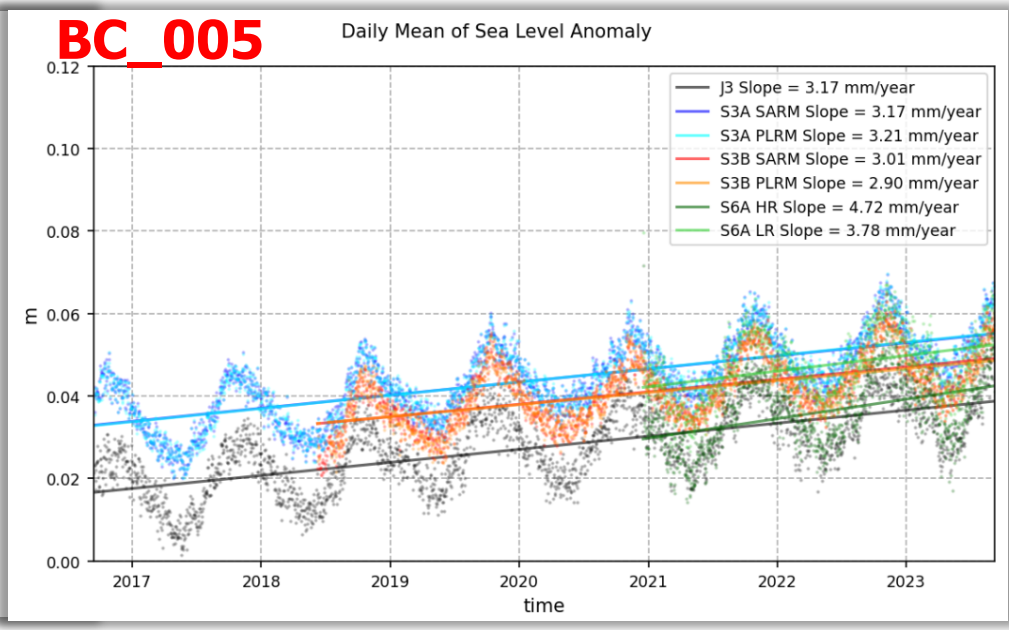
- Global Validation of the Jason-3 Mission: Current Status (*Nilsson et al.*)
  - Jason-3 performance are within defined parameters
  - No major impact on performance after change to interleaved orbit.
  - Observed change in SWH after orbit change; stabilizing after 1-year.
  - Overall good system performance (see also “Jason-3 GDR-F mission performances over ocean” from *Flamant et al.*)
- Excellent performances of the newly reprocessed ERS-1, ERS-2 and ENVISAT products for altimetry and radiometry: the FDR4ALT products *(Piras et al.)*
  - The newly reprocessed products show clear improvements with respect to the former datasets REAPER and ENVISAT V3.0.
  - One paper has already been published regarding performances of the Sea-Ice TDP (https://doi.org/10.5194/tc-17-3013-2023), and two others are in preparation (Land-Ice Paper & General project paper)
  - Products will be soon available to end users with the associated documentation by Q4 2023.
- Ongoing Validation and Recent Improvements to CryoSat Ocean Products *(Banks et al.)*
  - CryoSat-2 continues to provide high quality ocean data – SSHA, SWH and wind speed
  - Unique orbit provides complementary coverage to other altimetry missions
  - Long timeseries (now >13 years)
  - Baseline D will represent further improvements (see also poster: “CryoSat long-term ocean data analysis and validation: final words on GOP Baseline-C” (*Naeije et al.*))

Some Highlights from the Oral and Poster Sessions (global studies)

- Validation of Sentinel-3A/B baseline collection BC_005 over ocean (*Nencioli et al.*)
  - Geographically correlated errors (mm-scale) further mitigated
  - Improved overall SSHA performance:
    - Reduced x-over SSHA std
    - Removed small spectral bump
  - Greatly improved long-term SSHA stability (see next slide)
    - Sentinel-3A and Sentinel-3B long-term slopes aligned with reference missions (Jason-3 and Sentinel-6 MF)
    - Sentinel-3A and Sentinel-3B long-term slopes aligned with in-situ tide-gauge observations
  - Due to the recent full mission reprocessing, there is consistency from the beginning of the mission with the data currently being produced operationally

Sentinel-3 BC_005 improvements: Long-term SSHA stability

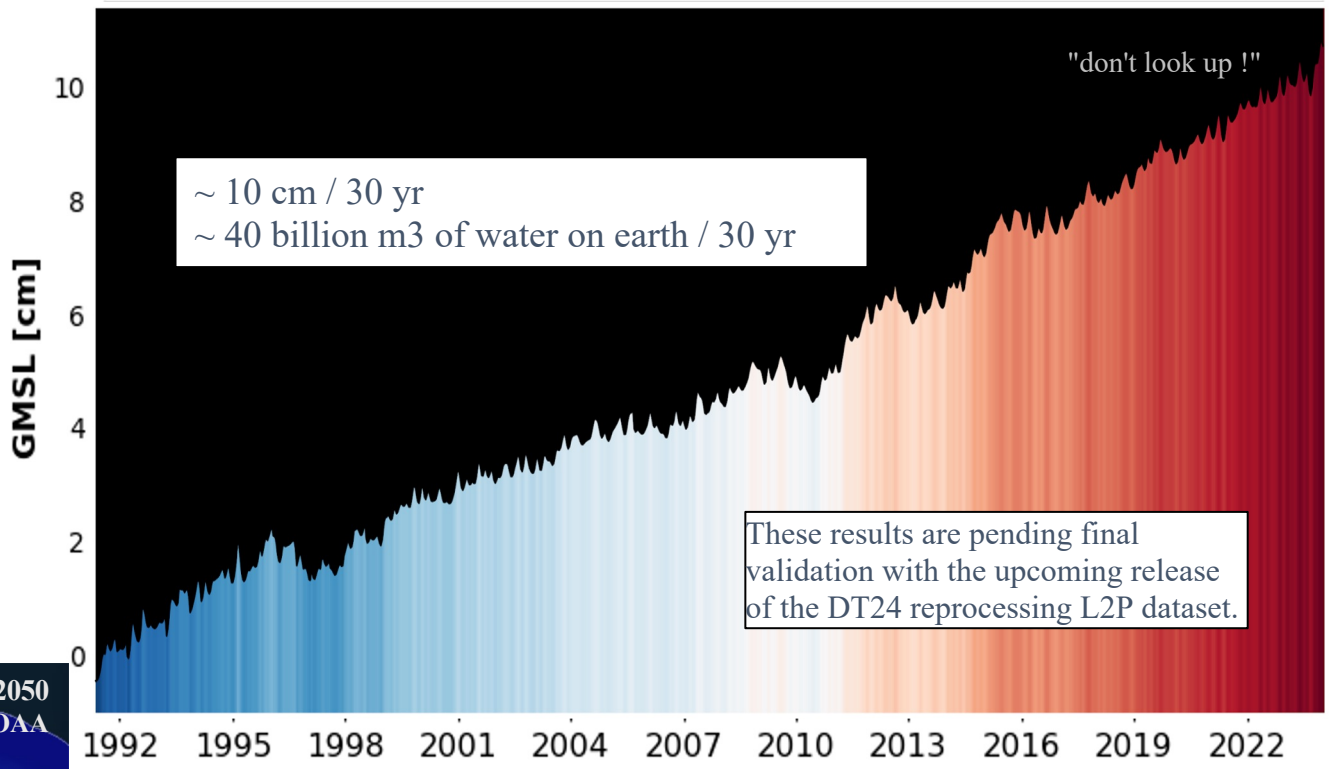




Some Highlights from the Oral and Poster Sessions (global studies)

- 30 years of sea level anomaly reprocessed to improve climate and mesoscale satellite data record (*Kocha et al.*)
  - DT24 reprocessing:
    - Mesoscale improvements particularly on coastal and polar regions
    - Ensuring continuity of mean sea level
  - The Global Mean Sea Level (GMSL) of reference has been recomputed with the new standard L2+ 2024 => will be soon available on AVISO (2024) (see *Quet et al*. poster "Estimation of the Topex A/B bias and associated uncertainty- A multi methods approach"), see next slide
  - Download data:
    - AVISO+ website https://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products/global/along-track-sea-level-anomalies-l2p.html
    - EUMETSAT website EUMETCAST
    - Copernicus website
      - https://resources.marine.copernicus.eu/product-detail/SEALEVEL_GLO_PHY_L3_NRT_OBSERVATIONS_008_044/INFORMATION
      - https://resources.marine.copernicus.eu/product-detail/SEALEVEL_GLO_PHY_L3_MY_008_062/INFORMATION
  - A higher resolution dataset is also available (1Hz -> 20Hz)==(7km->350m) (see poster "Homogeneous multi-mission 20Hz sea level anomaly products assessment" from *Kocha et al.*)
  - See also poster: How to get satellite data closer to insitu data on wind wave Copernicus service products (*Kocha et al.*)

Global Mean Sea Level (GMSL) of reference recomputed with the new standard L2+ 2024



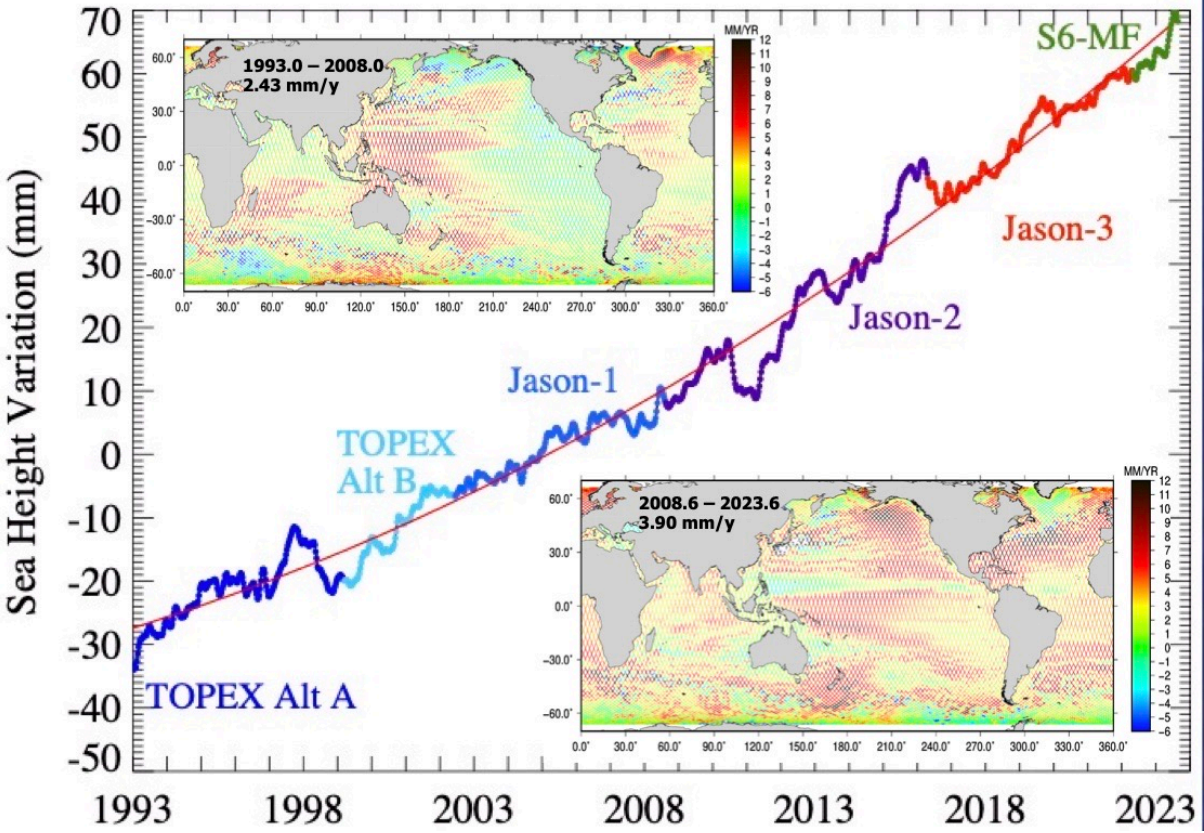
Some Highlights from the Oral and Poster Sessions (global studies)

- Validation of the reprocessed TOPEX GDR-F products (*Forster et al.*)
  - 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, for discussion on sea level rise impact see posters:
    - Beckley et al.: Assessment of Reprocessed TOPEX/Jason/Sentinel-6 Altimetry: Impact on Global Mean Sea Level Estimates (see also next slide)
    - Quet et al.: Estimation of the Topex A/B bias and associated uncertainty - A multi methods approach
    - Barnoud et al.: How to reach the scientific uncertainty requirements for scientific questions in future altimetry missions?

Assessment of Reprocessed TOPEX/Jason/Sentinel-6 Altimetry: Impact on Global Mean Sea Level Estimates (*Beckley et al.*)

Global mean sea level variations from 1993 to mid 2023 are estimated (*Beckley et al., 2017)* from TOPEX, Jason, and S6-MF (F08) altimetry based on GSFC std2006_cs21 orbits, TOPEX GDR_F data, and radiometer recalibrations discussed in the poster. The red line is the quadratic fit to the SSH variations after removal of annual and semi-annual signal and application of GIA. The linear sea level rate is estimated at 3.14 mm/y ± 0.4 mm/y with an acceleration of 0.096 mm/y2 ± 0.025 mm/y^2. Regional sea level rates are shown above (left inset) for the first 15-years and last 15-years (right inset) of the TOPEX/Jason/S6-MF sea surface height time series. The revised GMSL reduces the ocean mass budget misclosure during the GRACE Follow-On (GFO) era by ~ 40 % (RMS reduction of 2.2 mm).



Some Highlights from the Oral and Poster Sessions (global studies)

- Jason-2 GDR-F reprocessing impact on mission performances over ocean (*Roinard et al.*)
  - Very good performances of reference MLE4 Jason-2 GDR-F SLA
  - Improvements are allowed using adaptive retracker outputs
    - SLA ADAPTIVE data are globally more valid than SLA MLE4 data
    - Taking into account valid data in both datasets points, performances are better with adaptive solution than with MLE4 :
      - variance of SSH difference at crossovers is reduced by -0,5cm^2
      - variance of along-track 1Hz SLA is reduced by -0,7cm^2
- Jason-3 GDR-F mission performances over ocean (*Flamant et al.*)
  - Very good performances of reference MLE4 Jason-3 GDR-F SLA
    - No visible degradation of the products due to the instruments ageing
    - Almost no impact of the new orbit on the performance
  - Improvements are allowed using adaptive retracker outputs
    - SLA ADAPTIVE data are globally more valid than SLA MLE4 data (using recommended in handbook procedure)
    - Taking into account valid in both datasets points, performances are better with adaptive solution than with MLE4, over 7 years (2016/02 to 2023/02) of data: variance of along-track 1Hz SLA is reduced by 0,13cm^2
- Global Ocean Data Quality Assessment of SARAL/AltiKa's GDR-F products (*Philipps et al*.)
  - The SARAL/AltiKa mission is now in the middle of its eleventh year and has been on a drifting orbit for more than seven years.
  - Mission performance remains excellent, compared to Jason-2 and Jason-3.
- Haiyang-2D data assessment and performance for potential assimilation into DUACS and CMEMS products (*Philip et al*.)
  - Results obtained show promising data quality, in agreement with the previous HY-2B and HY-2C satellites and making HY-2D a good candidate for a potential integration in the multi-mission's products

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