A test case for correcting coherent and incoherent tides in altimetry data using MIOST

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Introduction Internal tide (IT) can be separated into two parts: a coherent (stationary) part, which remains in phase with the barotropic tide, and an incoherent (non-stationary) part, which varies with the propagation environment. Global IT atlases such as HRET22 (High-Resolution Empirical tide 22; Zaron and Elipot 2024) and MIOST-IT24 (Multivariate Inversion of Ocean Surface Topography -IT24 ,Tchilibou et al.,2025), built from nearly 30 years of altimetric SLA (sea level anomaly), correct only the long-term stationary IT, leaving residual incoherent IT. This work aims to contribute to the improvement of the correction of the incoherent IT in altimetry. We present a test case correcting the coherent IT with HRET22 and the incoherent IT using MIOST inversion over a short period (15 days or 1 month). The two-step correction is compared with the standard single correction commonly applied. We focus exclusively on the M2 tide.

1- Method and data

Single correction

SLA ──► Correction with Reference Atlas HRET22

└─► Corrected SLA

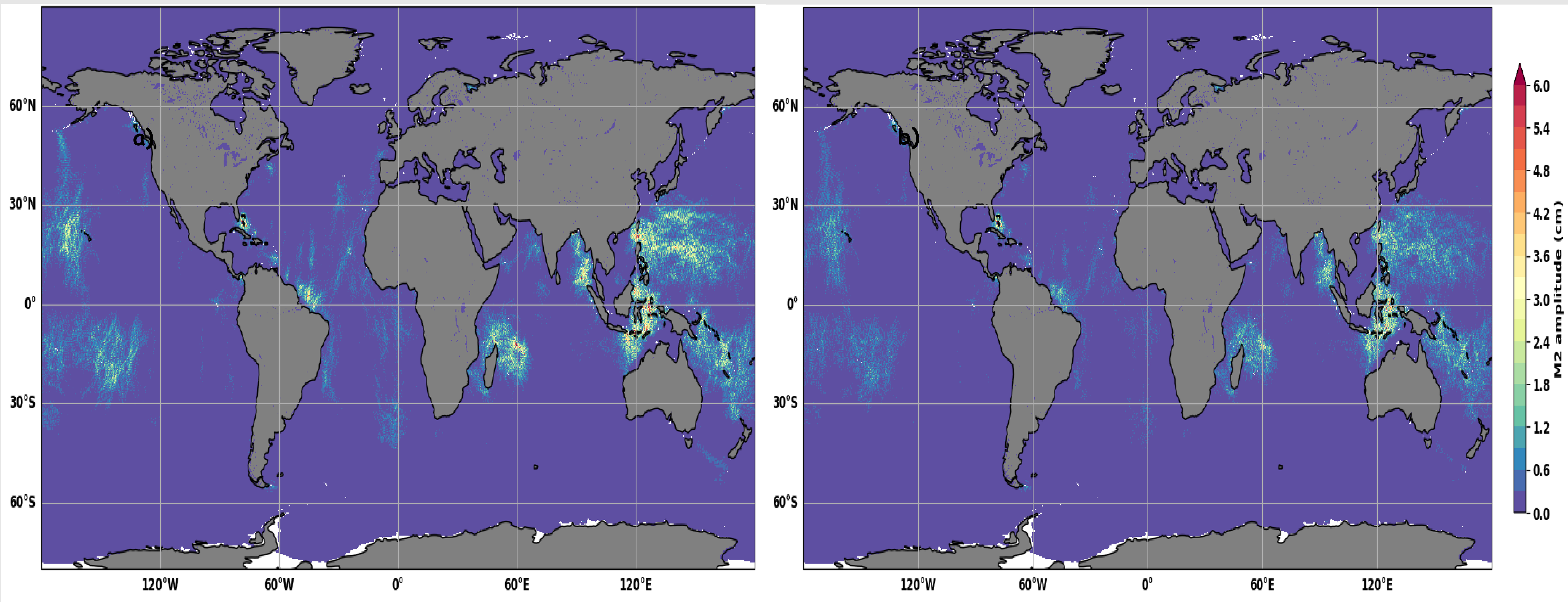
Two-step correction

SLA ──► Step 1: Correction with Reference Atlas HRET

└─► Residual SLA ──► Step 2: Build Residual Atlas with MIOST applied locally every 15-days or month

└─► Apply Residual Atlas Correction

└─► Corrected SLA



- The residual SLA atlas is derived from inversions of the residual SLA from six satellite missions (C2, H2b, J3, S3a, S3b and S6a) over the 2023–2024 period. The inversions are carried out at two temporal resolutions: monthly and 15-day intervals.
- The same IT generation and propagation regions can be identified in both the total and monthly residual SLA. The residual SLA amplitude reaches up to 2 cm in some locations.

Fig 1: Amplitude of the M2 IT for January 2023 (Units: cm). **a)** monthly atlas obtained from the inversion of total SLA. **b)** monthly atlas obtained from the inversion of residual SLA.

3- Validation

The validation relies on independent datasets, SWOT 1-day Cal/Val data (April–June 2023) and the SARAL/AltiKa mission covering the full year 2023. Figure 2 presents the validation results obtained with SWOT track 20 in the Amazon region.

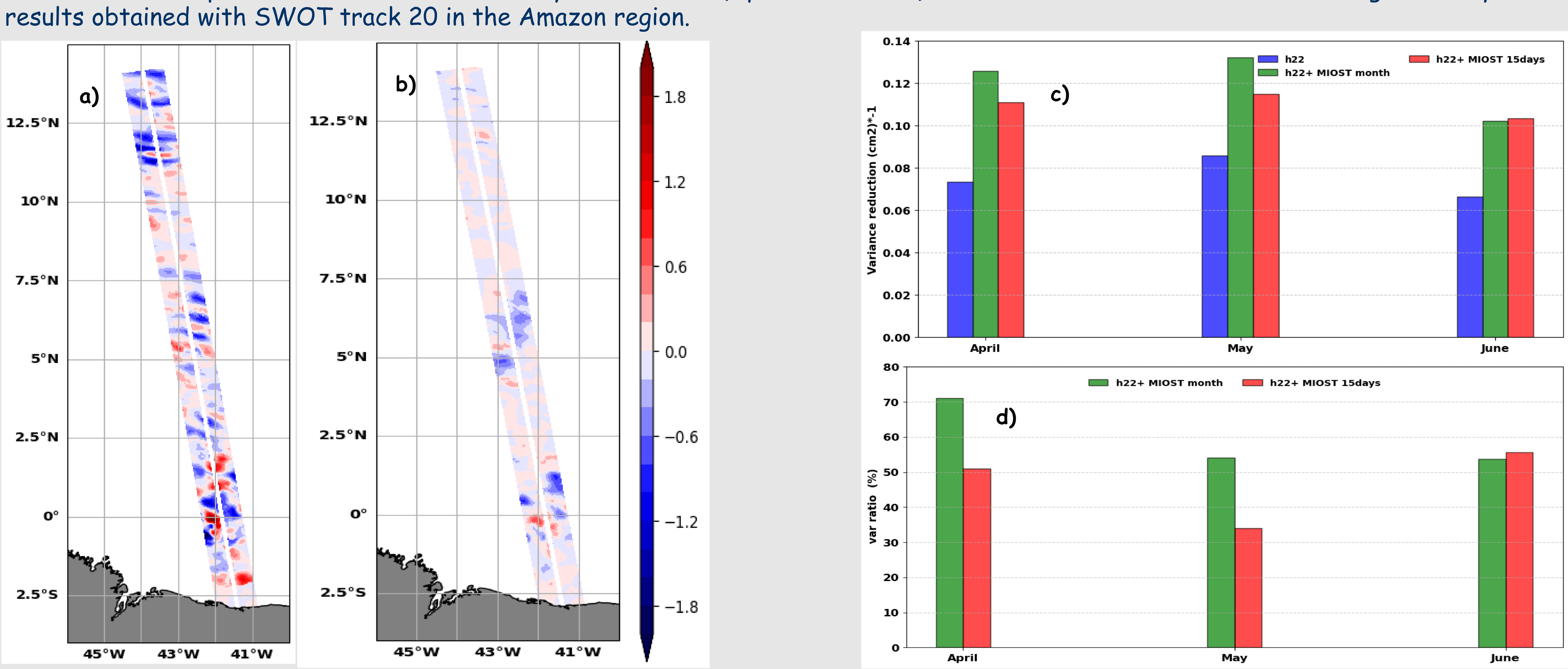


Fig 2: a) Variance reduction (cm2) for March 2023: var (SLA – HRET22 - MIOST monthly) – var (SLA). **b)** Difference of variance reduction (cm2): Var (SLA-HRET22 –MIOST) – Var (SLA –HRET22). **c)** Bar plot of the spatial mean (cm2) along SWOT track of monthly variance reduction: Single correction with HRET22 (blue) and two-step correction using monthly (green) or 15-days (red) MIOST inversion. **d)** Bar plot showing the improvement (%) achieved with the two-step correction compared to the single correction. Green: MIOST monthly inversion; Red: MIOST 15-day inversion.

- Blue shading indicates regions where the two-step correction achieves variance reduction relative to SLA (Fig. 2a) and to the single correction (Fig. 2b).
- The two-step correction is more effective than the single correction (Fig 2c), strongly removing additional IT signal along the track south of 2.5°N and between 5°N and 7°N (Fig 2b).
- On average, the two-step correction with MIOST monthly inversion is more effective than that with MIOST 15-day inversion (Fig 2c).
- The two-step correction removes an additional 30–70% of variance compared to the single correction (Fig 2d).

Conclusion and perspectives A two-step internal tide (IT) correction method, combining a long-term atlas (HRET22) with a short-term atlas derived from MIOST inversion of SLA already corrected for IT, was tested. This confirms the presence of residual IT signals in altimetric SLA, reaching up to 2 cm. The two-step correction provides an additional 30–70% variance reduction in SLA along track 20 of the 1-day SWOT data off the Amazon. Similar results (not shown) were obtained at the global scale using SARAL/AltiKa data. At this stage, performing a MIOST monthly inversion on SLA already corrected for IT with HRET22 appears to be the most effective approach. Future work should extend this test to additional tidal constituents (e.g., S2, N2, K1, O1) and include further diagnostics, such as spectral analyses, to more comprehensively evaluate the impact of the two-step correction. Other long-term atlases could also be tested, and it remains to be determined whether the two-step correction fully removes the incoherent tide. Analyses are currently underway to investigate the extent to which mesoscale variability contaminates the monthly and 15-day MIOST-IT solutions.

References: **Tchilibou, M.,** Barbot, S., Carrere, L., Koch-Larrouy, A., Dibarboure, G., and Ubelmann, C.: M2 monthly and annual mode-1 and mode-2 internal tide atlases from altimetry data and MIOST: focus on the Indo-Philippine archipelago and the region off the Amazon shelf, Ocean Sci., 21, 1469–1486, https://doi.org/10.5194/os-21-1469-2025, 2025. **Zaron, E. D. and Elipot, S.**: Estimates of Baroclinic Tidal Sea Level and Currents from Lagrangian Drifters and Satellite Altimetry, J. Atmos. Oceanic Technol., 41, 781–802, https://doi.org/10.1175/JTECH-D-23-0159.1, 2024.