Exploring the Opportunities of Geostrophic Current Observations from Space in the Joint Estimation of Mean Dynamic Topography and Geoid Undulation

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Abstract

The mean dynamic topography (MDT) and the static marine geoid are important reference surfaces for a variety of ocean studies, their computation thus highly valued. Space-based observations of the dynamic topography in terms of surface geostrophic currents bring huge potential for improvements.

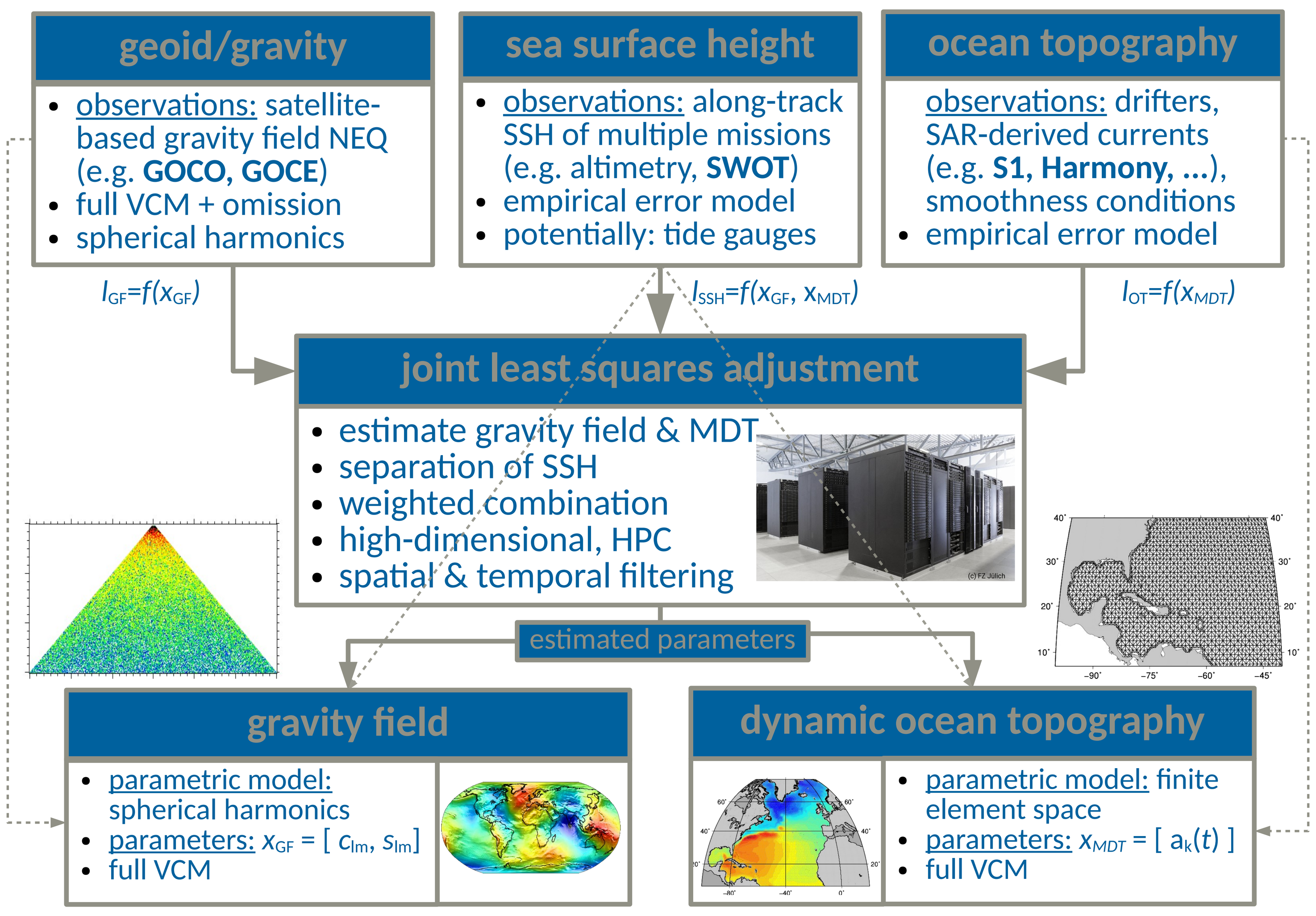
In this contribution we simulate the impact of sparsely sampled, line-of-sight (LOS) surface geostrophic current observations as possibly acquired via Sentinel-1's (S1) WV-mode Radial Velocities (RVL) on the joint estimation of a "geodetic" MDT [1] and the geoid's undulation within the parametric least-squares framework [2].

Based on the latest CNES-CLS18 MDT [8] we compute "true" LOS current velocities for one year of Sentinel-1 observation geometry and add reasonably optimistic noise of 0.1 m s^{-1} and 0.25 m s^{-1} [6]. These are directly mapped to the spatial gradient of the parametric MDT model function (a C^1-smooth Finite Element Space) in terms of observation equations.

We present four regional MDT solutions and their formal errors, all based on ten years of multi-mission altimetry (Jason-1 to 3 and Cryosat-2 L2P by AVISO) supplemented by the GOCO06s gravity field [5], but each differently augmented with (exclusive) information about the MDT.

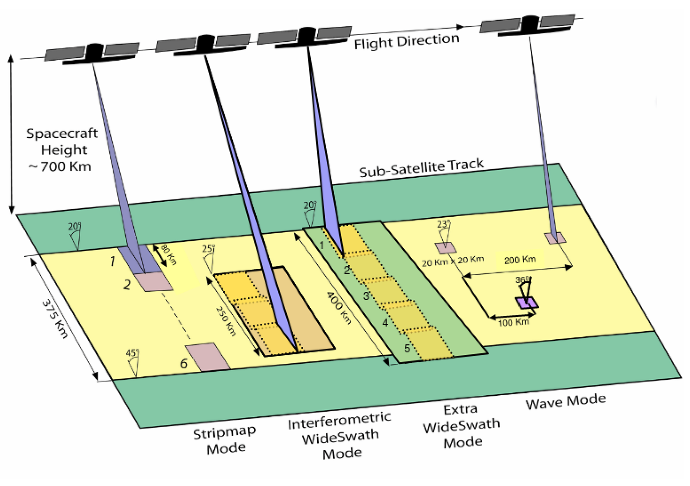
The results demonstrate that geostrophic RVL as complementary observations significantly improve the separation even with the sparsity of S1's WV-mode.

Parametric Least-Squares for the Geodetic Approach

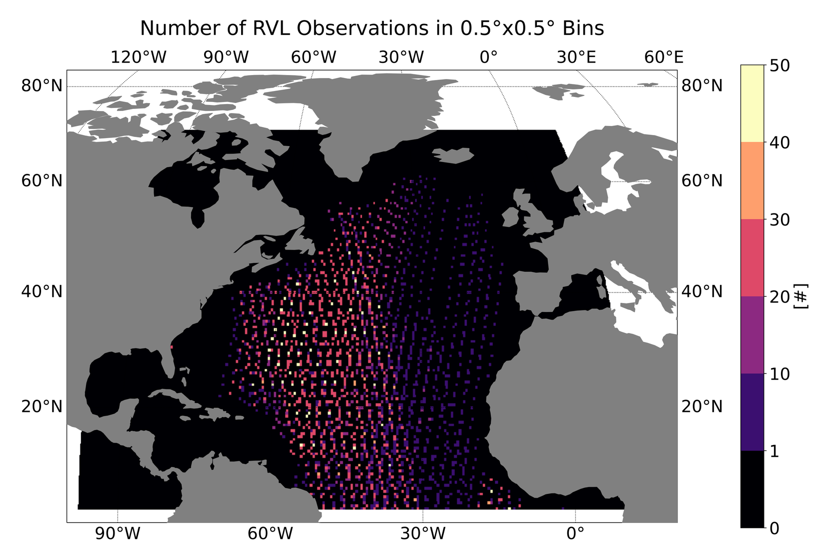


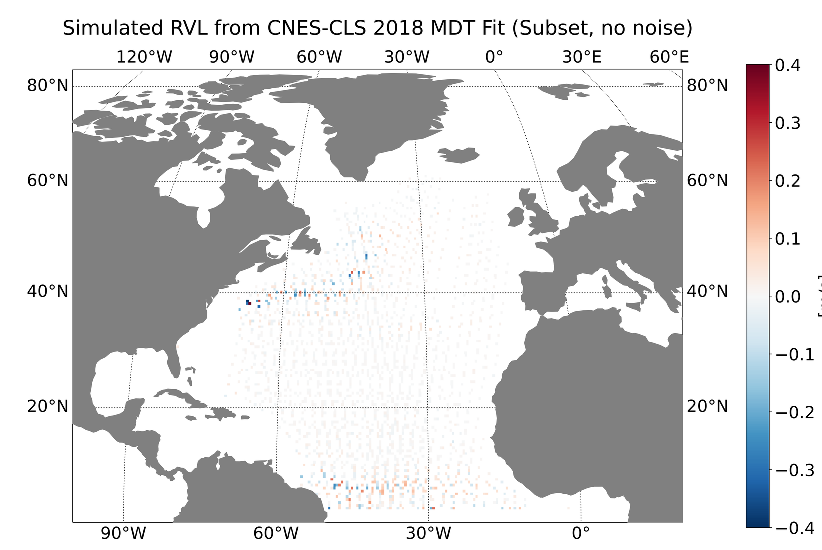
Model Setup and Input

- MDT: C^1-smooth Finite Element Space
- Geoid: degree/order 600 Spherical Harmonics
- GOCO06s normal equations (d/o 300)
- About 55 million SSH observations
- SSH $=$ MDT $+$ Geoid $+$ Bias
- About 27k simulated Wave Mode RVL
- LOS projection in Geostrophic Approximation: $u_{\mathbf{r}} = \langle \frac{g}{f} \mathbf{R} \nabla \mathrm{MDT}, \mathbf{r} \rangle$



Sentinel-1 Acquisition Modes [4]





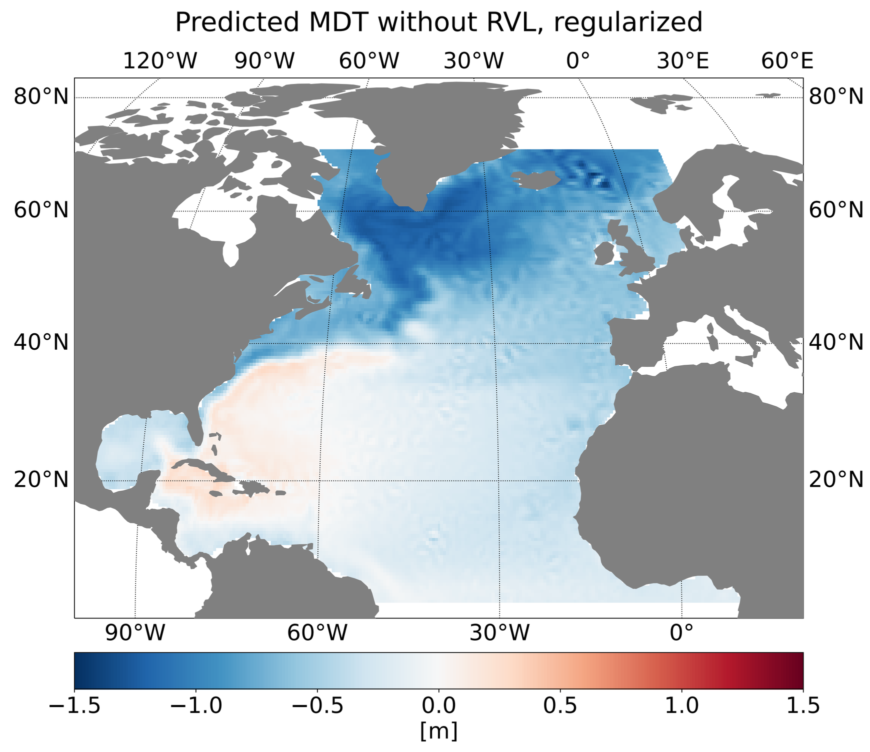
Results

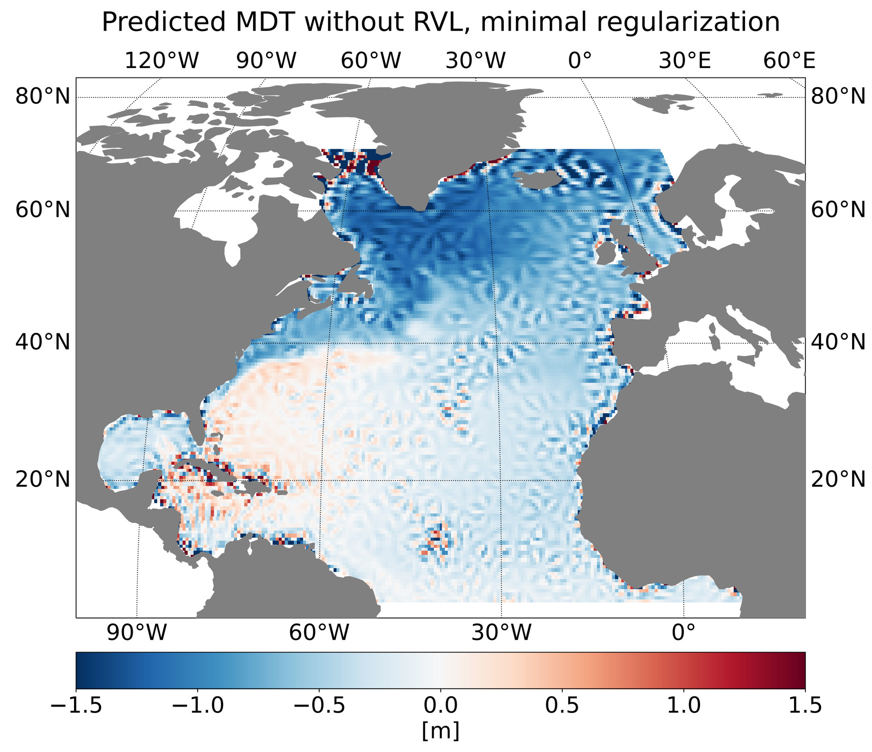
1) full regularization of MDT's smoothness

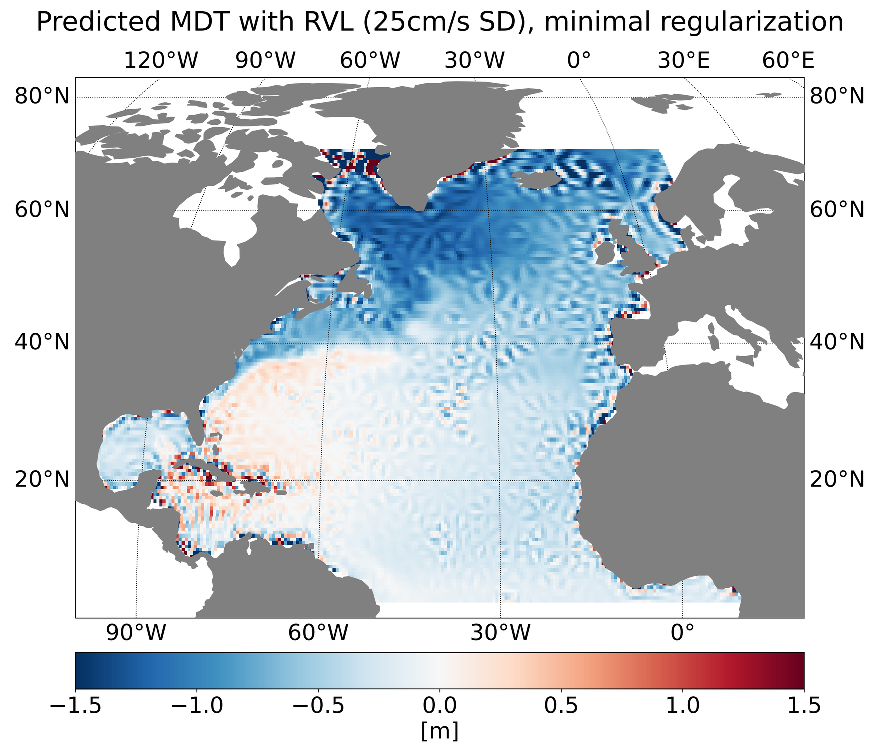
2) numerically constrained MDT

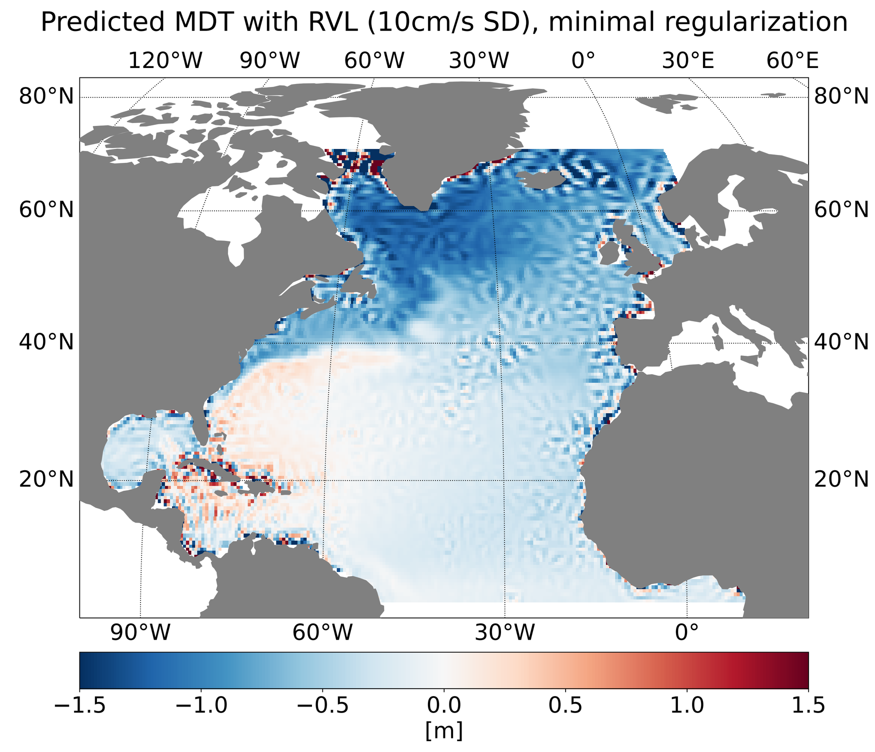
3) simulated RVL (0.25 m s^{-1} SD) + 2)

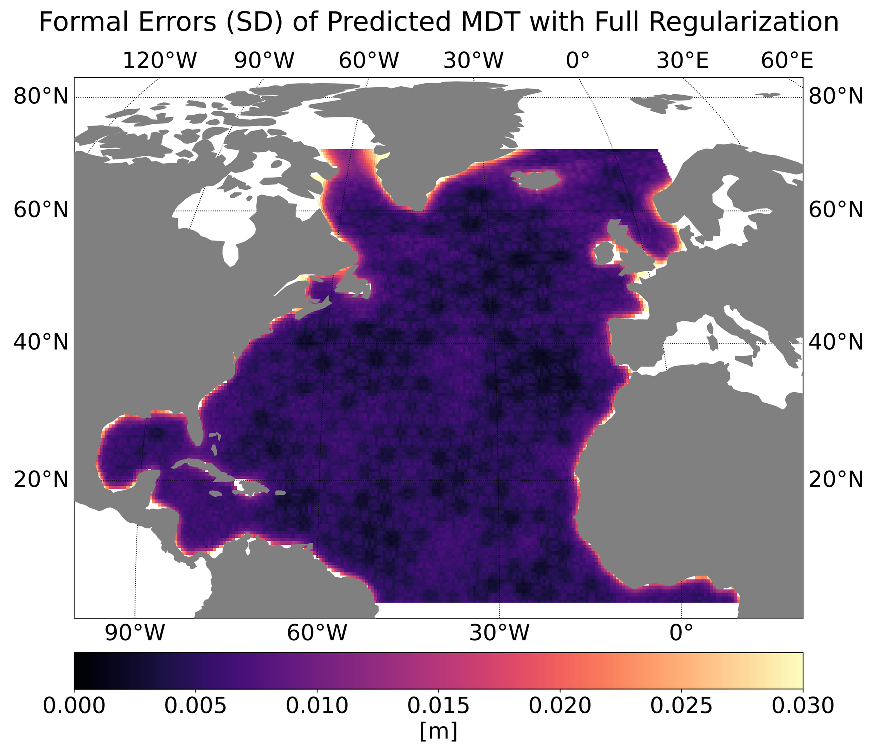
4) simulated RVL (0.10 m s^{-1} SD) + 2)

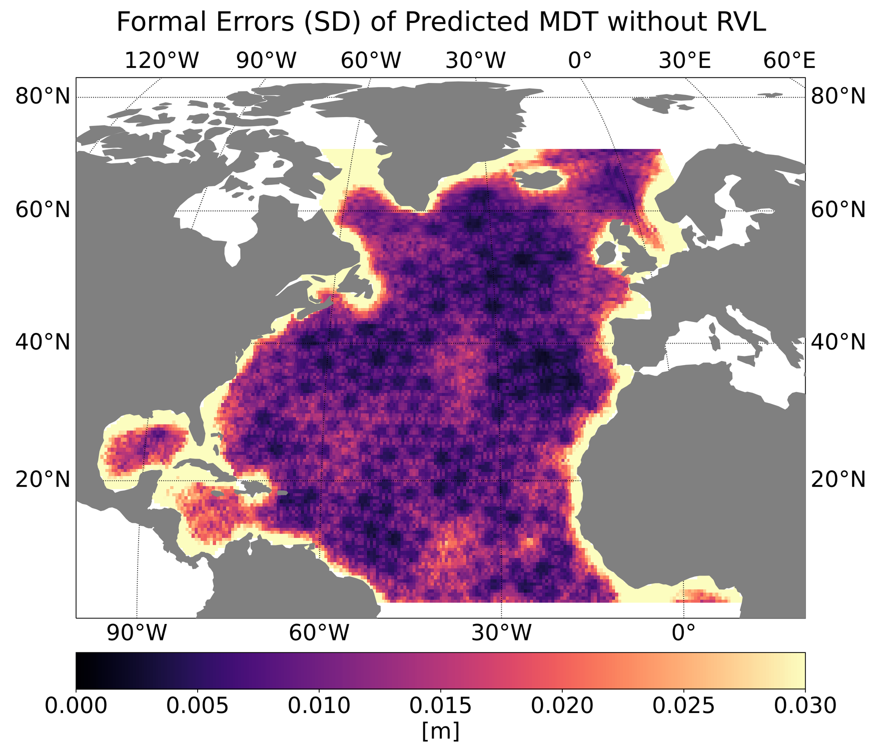


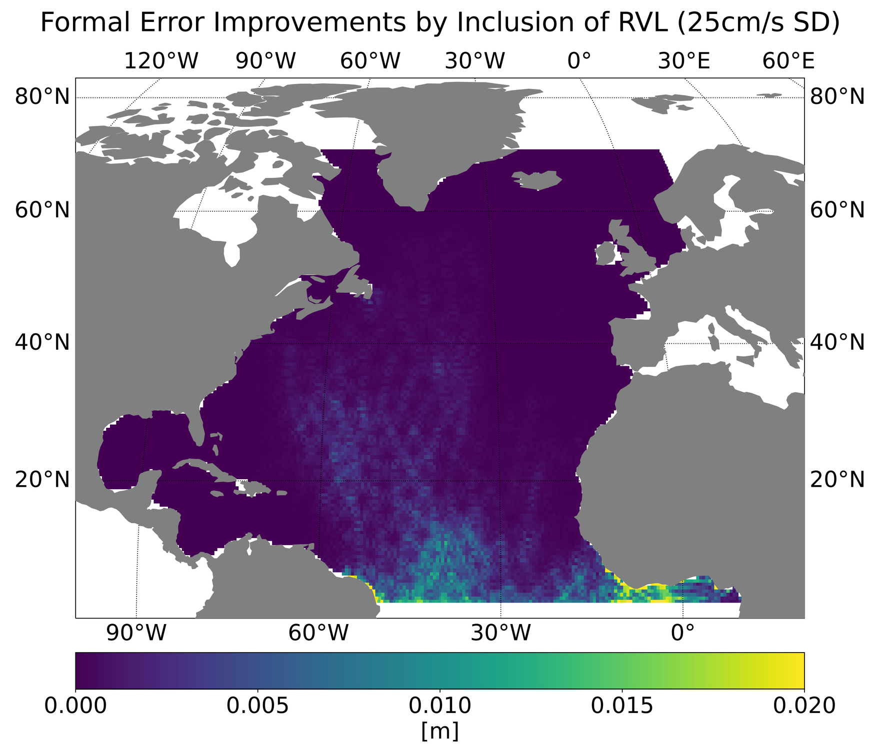


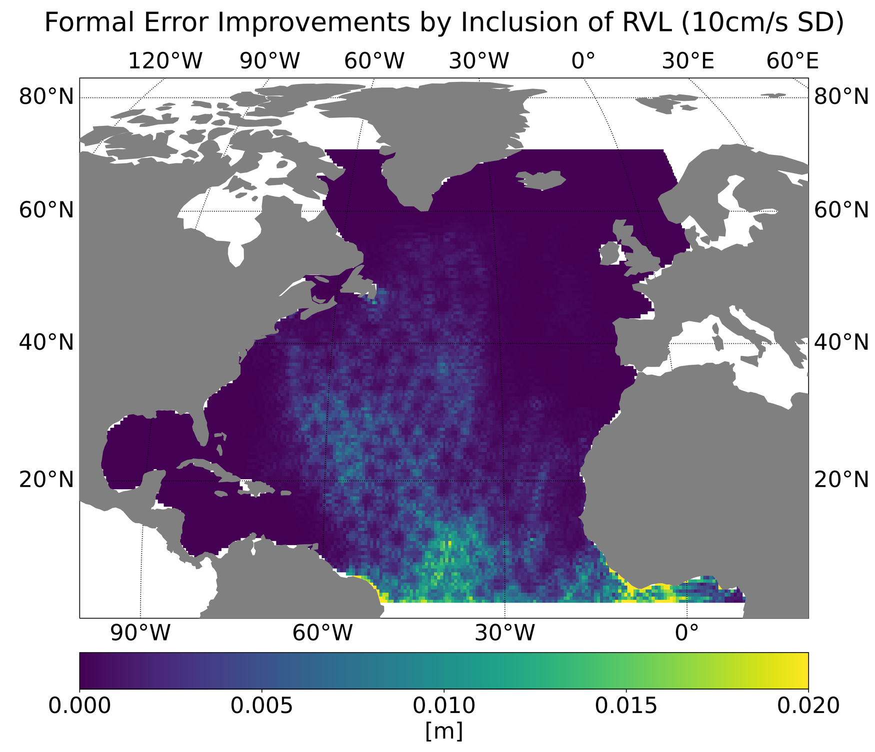












Summary and Conclusions

This study demonstrates significant potential of geostrophic RVL observations for the "geodetic" estimation of the MDT.

- RVL are straightforward to integrate into the parametric least-squares framework
- where available, RVL can successfully "replace" regularization

We therefore strongly recommend further research to enable exploitation of operational surface current products.

- ageostrophic components and disturbing signals require correction and calibration
- S1 L2 processor currently yields insufficiently calibrated RVL [3]
- calibration in post-processing is being developed and evaluated [3, 6, 7]
- EE10 Harmony and EE11 SEASTAR proposals set out to observe vector field current data

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Acknowledgments

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