The first validation of NMBU23 – an updated coastal mean sea surface in Norway based on combination of new-generation laser and radar altimetry

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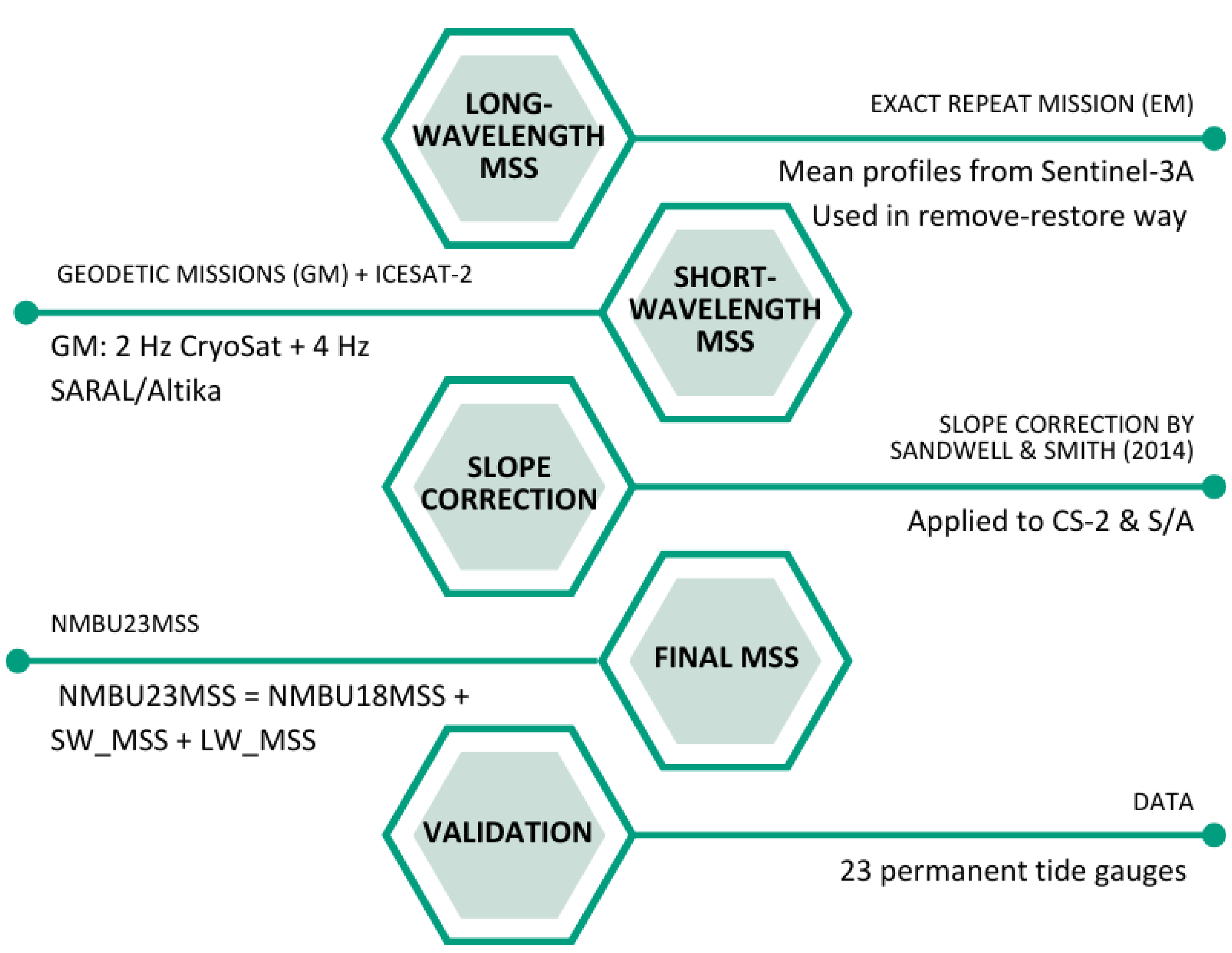
Abstract

The coastal mean sea surface (MSS) has a wide range of applications within geodesy and oceanography, such as geodetic mapping of ocean currents, calculations of marine gravity anomalies and bathymetry estimates. Moreover, it connects the open-ocean MSS from altimetry and tide gauge measurements at or close to the land and serves as a crucial factor in unifying vertical reference frames. Nowadays, available MSS models are mostly based on observations from radar altimetry, which enables the determination of the mean sea surface to centimeter accuracy in the open sea. Although the new generation of radar altimetry missions equipped with Synthetic Aperture Radar (SAR) are able to provide measurements every 300 m in the along-track direction, its performance is degraded in coastal areas due to different factors, such as land contamination, erroneous tropospheric corrections or complex tidal patterns. The Norwegian coastline, known as the second longest and one of the most rugged coastline in the world, introduces many challenges for using radar satellite altimetry, which in the end results in reduced number of valid altimetry observations. In 2018, the National Aeronautics and Space Administration launched ICESat-2, a laser altimetry mission equipped with the Advanced Topographic Laser Altimeter System, providing measurements every 0.7 m in the along-track direction. Due to its small footprint, ICESat-2 has the potential to fill the observation gap between tide gauges and the open sea. Therefore, we have determined an updated MSS model by combining observations from radar altimetry missions (Sentinel-3, CryoSat-2 and SARAL/AltiKa) used to create an existing MSS for Norway, NMBU18, with ICESat-2 observations. Finally, we have used NMBU18 and observations from the Norwegian network of permanent tide gauges to validate the updated MSS model.

What has been done?



Preliminary results

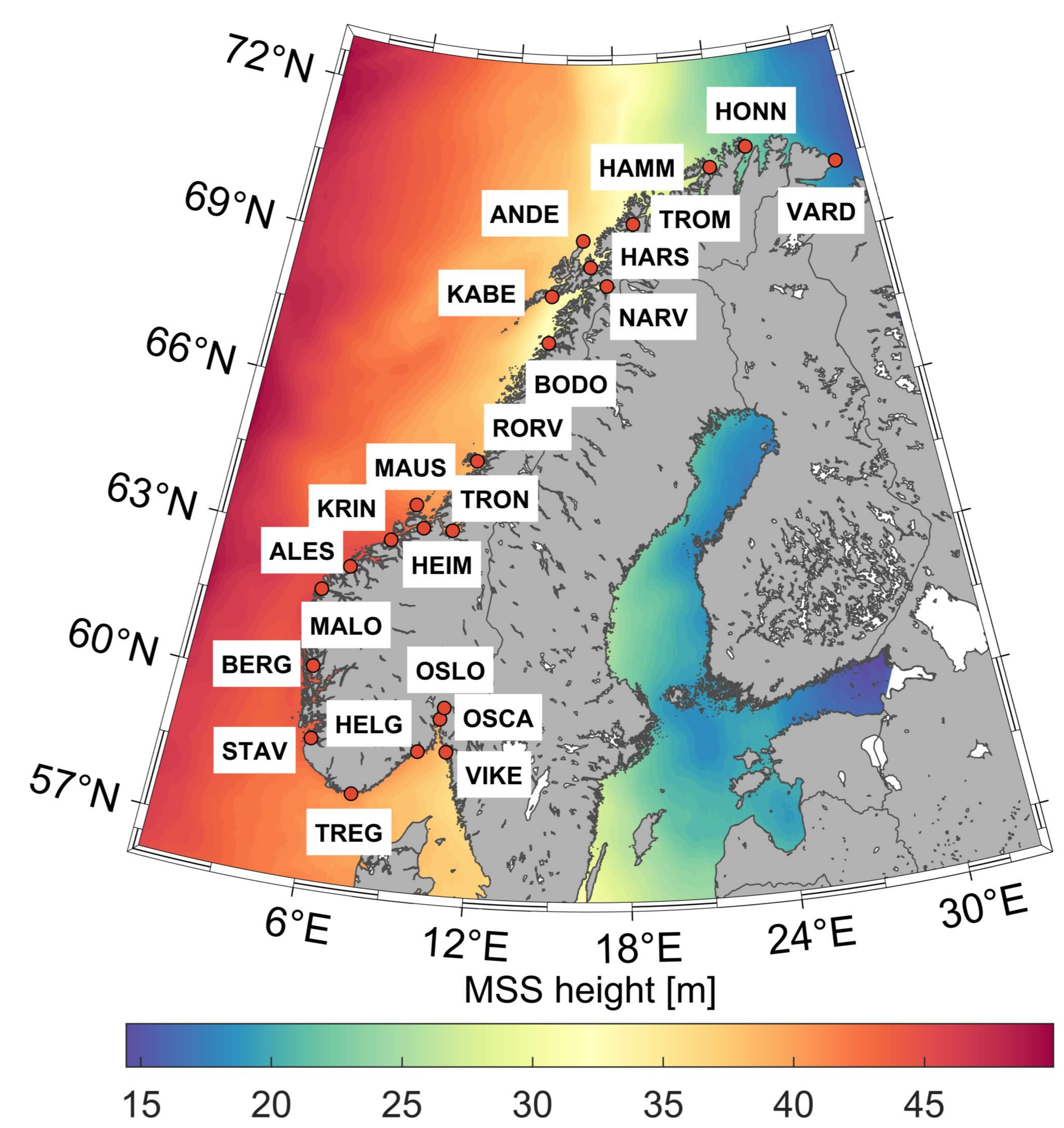


Figure 1. *The mean sea surface for Norway for the period 2010–2023 from combination of radar and laser altimetry observations with marked locations of permanent tide gauges used for validation.*

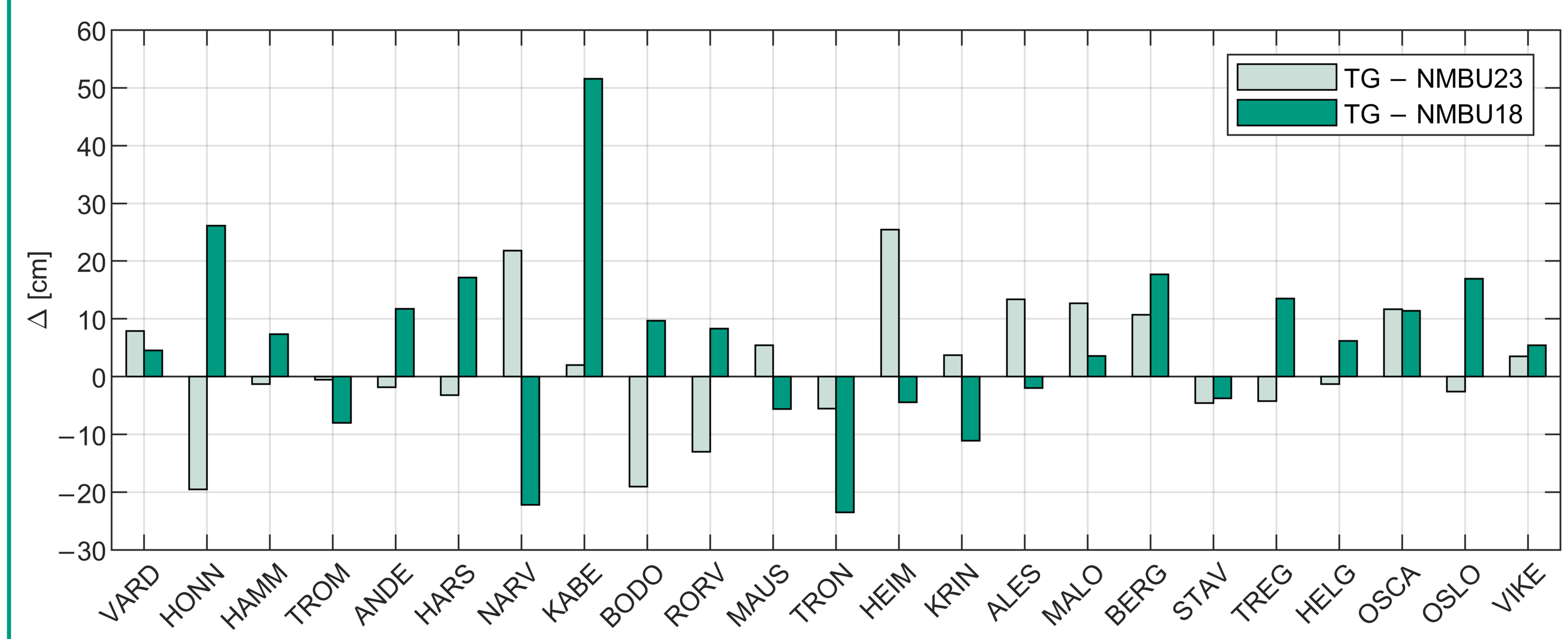


Figure 2. *The height difference between permanent tide gauges and NMBU MSS models.*

MODEL	MIN [cm]	MAX [cm]	MEAN [cm]	STD [cm]
NMBU18MSS	-23.5	51.6	5.7	15.9
NMBU23MSS	-19.5	25.4	1.8	11.2

Table 1. *Statistics of differences between the MSL observed by permanent tide gauges along the Norwegian coast and MSS from altimetry.*

Results and discussion

- NMBU23MSS based on the combination of radar altimetry and ICESat-2 observations shows better agreement with tide gauges than the previous MSS model, NMBU18 in terms of standard deviation of differences
- The biggest improvement observed at tide gauges inside fjords (NARV, TRON, OSCA, OSLO)
- Determination of the formal error field is necessary
- Expected improvement of MSS accuracy in the future by incorporating more ICESat-2 observations

References

- Bagnardi, M.; Kurtz, N.T.; Petty, A.A.; Kwok, R. Sea Surface Height Anomalies of the Arctic Ocean From ICESat-2: A First Examination and Comparisons With CryoSat-2. Geophys. Res. Lett. 2021, 48, 93155. https://doi.org/10.1029/2021GL093155
- BuMorison, J.H.; Hancock, D.; Dickinson, S.; Robbins, J.; Roberts, L.; Kwok, R.; Palm, S.P.; Smith, B.; Jasinski, M.F.; the ICESat-2 Science Team. ATLAS/ICESat-2 L3A Ocean Surface Height, Version 4; National Snow and Ice Data Center: Boulder, CO, USA, 2021.
- Morison, J.; Dickinson, S.; Hancock, D.; Robbins, J.; Roberts, L. ICESat-2 ATL12 Ocean Surface Height and ATL19 Gridded Dynamic Ocean Topography. In Proceedings of the OCEANS 2022, Hampton Roads, VA, USA, 17–20 October 2022; pp. 1–6. doi: 10.1109/OCEANS47191.2022.9977076.
- Ophaug, V.; Breili, K.; Andersen, O.B. A coastal mean sea surface with associated errors in Norway based on new-generation altimetry. Adv. Space Res. 2021, 68, 1103–1115. https://doi.org/10.1016/j.asr.2019.08.010
- Tomić, M.; Baltazar Andersen, O. ICESat-2 for Coastal MSS Determination—Evaluation in the Norwegian Coastal Zone. Remote Sens. 2023, 15, 3974. https://doi.org/10.3390/rs15163974

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