ICESat-2 for Coastal MSS Determination—Evaluation in the Sognefjord section of the Norwegian Coastal Zone

Matea Tomić[1], Ole Baltazar Andersen[2]

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[1]Faculty of Science and Technology, Norwegian University of Life Sciences (NMBU), Ås, Norway

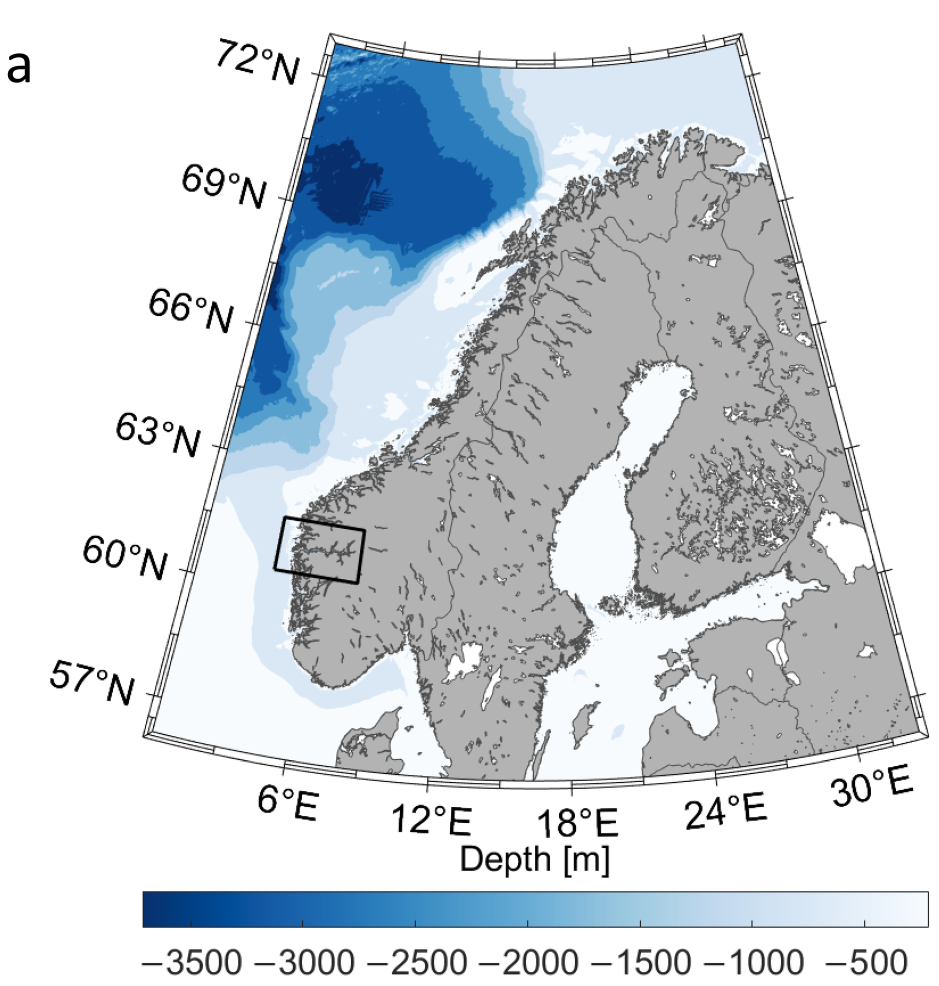
[2] DTU Space, Technical University of Denmark, Kongens Lyngby, Denmark

Abstract

Radar satellite altimeters enable the determination of the mean sea surface to centimeter accuracy, which can be degraded in coastal areas because of the lack of valid altimetry observations due to land contamination and the altimeter footprint size. 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. Taking into account the complexity of the Norwegian coastline, this study aims to evaluate coastal observations from ICESat-2 in order to use it to update the existing mean sea surface for Norway, NMBU18. We, therefore, determined the mean sea surface using only ICESat-2 observations and compared it with mean sea level observations from 23 permanent tide gauges along the entire coast and 21 temporary tide gauges in Norway's largest and deepest fjord, Sognefjorden. We also included two global mean sea surface models and NMBU18 for comparison. The results have shown that ICESat-2 is indeed able to provide more valid observations in the coastal zone, which can be used to improve the mean sea surface model, especially along the coast.

Study Area

a



b

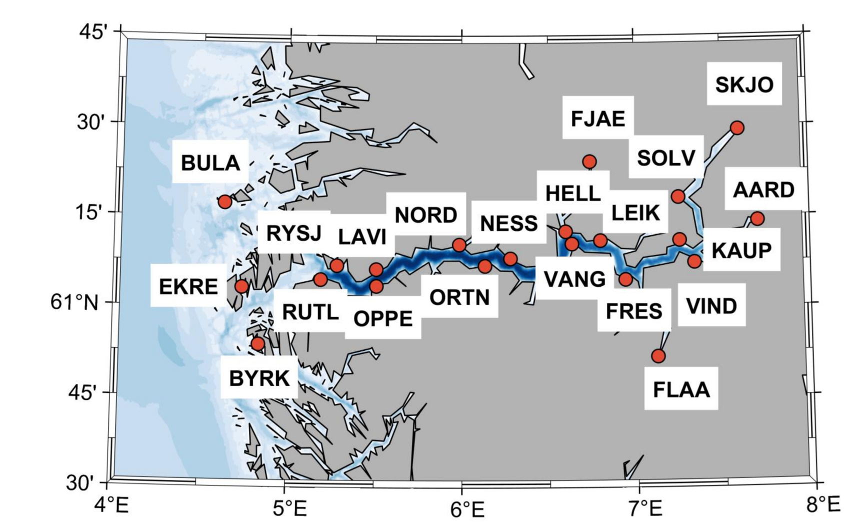


Figure 1. The study area of the Norwegian coast (a) and locations of 21 temporary tide gauges inside Sognefjorden (b) used in this study. Bathymetry is taken from the 2021 General Bathymetric Charts of the Oceans (GEBCO)

Results

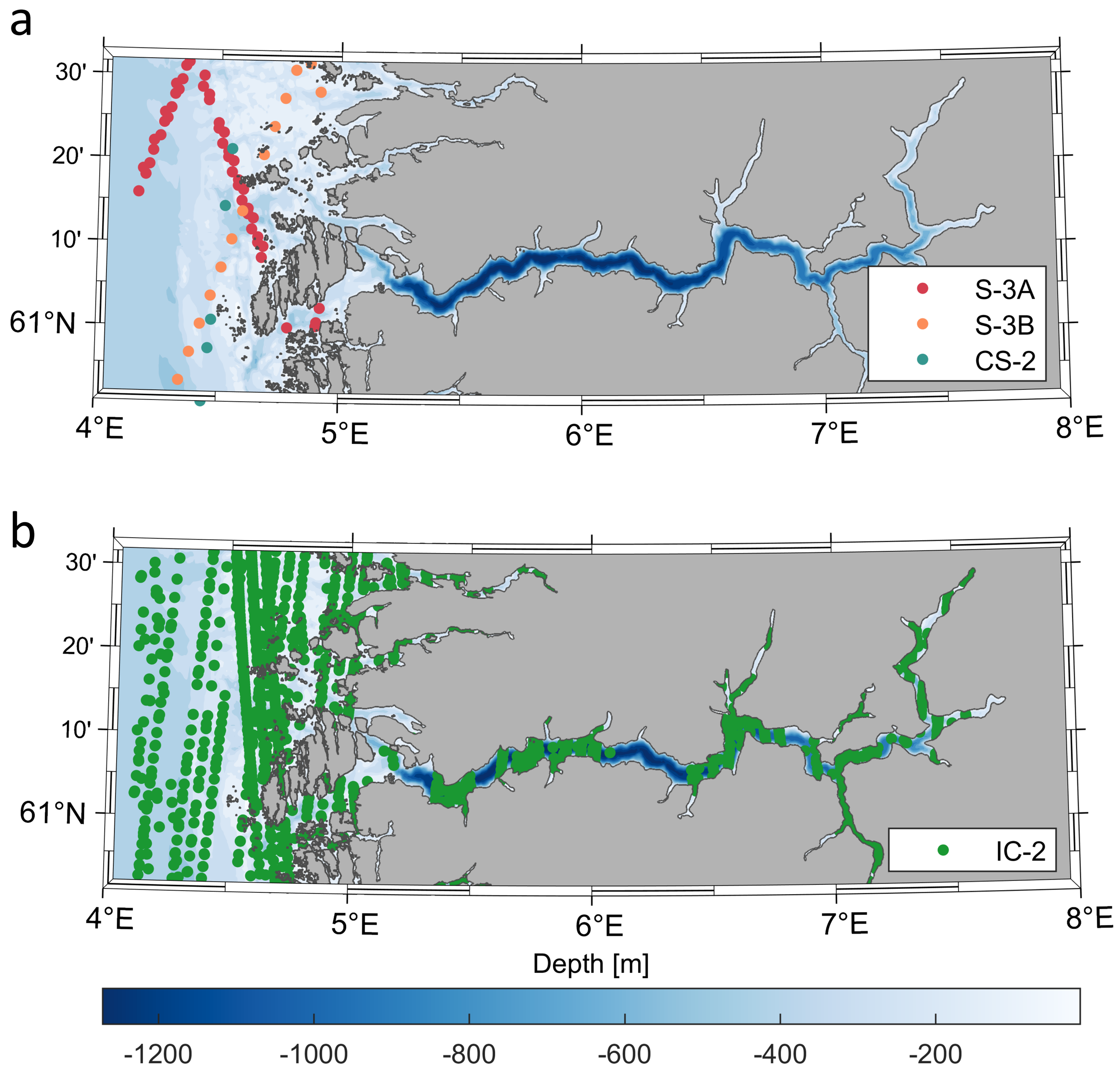


Figure 2. Locations of non-processed Sentinel-3/CryoSat-2 (a) and ICESat-2 (b) observations inside Sognefjorden during 2020.

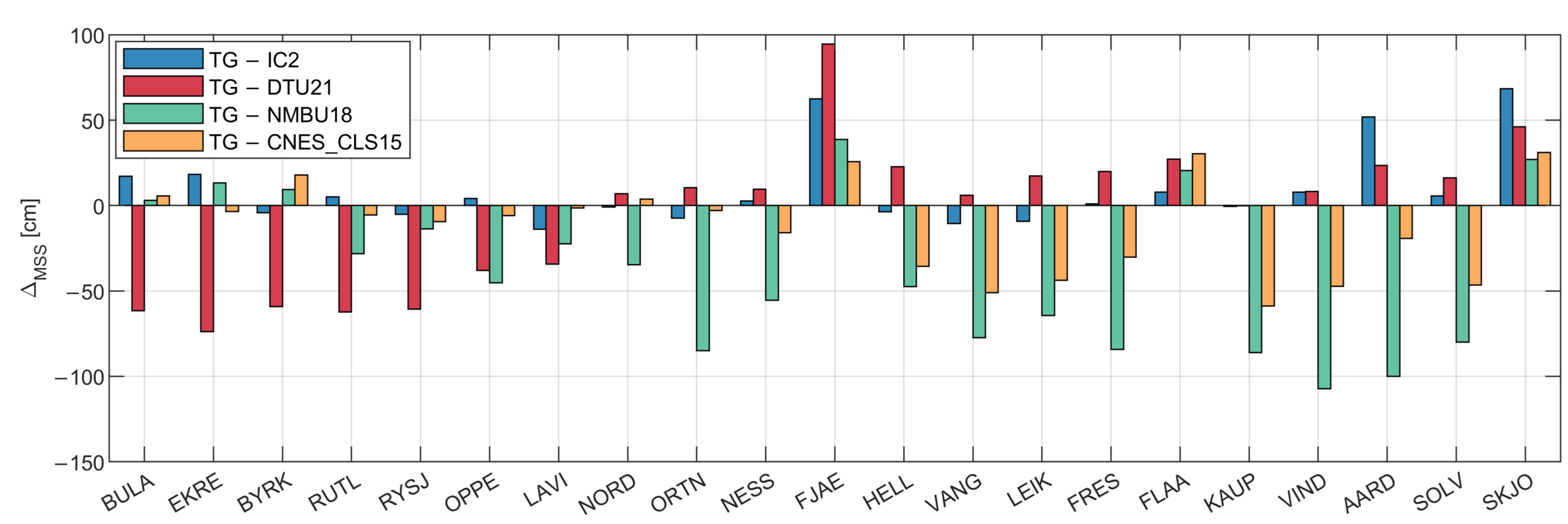


Figure 3. The height difference between temporary tide gauges and the IC-2 MSS model inside Sognefjorden.

Δ	MIN [cm]	MAX [cm]	MEAN [cm]	STD [cm]
TG – IC2	-13.8	68.3	9.4	23.2
TG – DTU21	-73.8	94.5	-3.9	42.9
TG – NMBU18	-107.3	38.8	-39.0	45.2
TG – CNES_CLS15	-58.7	31.1	-12.5	21.7

Table 1. Statistics of differences between the MSL observed by temporary tide gauges inside Sognefjorden and MSS from altimetry.

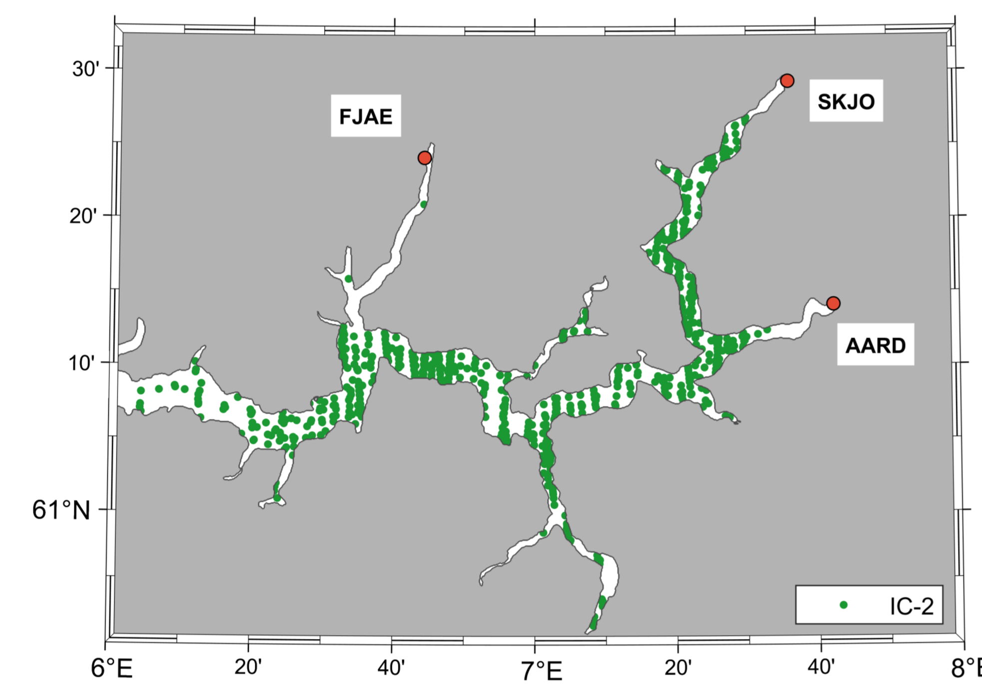


Figure 4. Branches of Sognefjorden with available ICESat-2 observations.

Conclusions and outlook

- ICESat-2 able to provide more observations inside the largest Norwegian fjord, Sognefjorden than laser altimetry missions (e.g. missions equipped with SAR - CryoSat-2 and Sentinel-3)
- MSS created only from ICESat-2 observations outperforms two global and NMBU18 MSS models in comparison with temporary tide gauges inside Sognefjorden
- The largest differences observed at tide gauges without available ICESat-2 observations (FJAE, SKJO, AARD)
- Expected improvement of MSS accuracy in the future by incorporating more ICESat-2 observations

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Acknowledgments

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