



Supplement of

A Bayesian approach towards daily pan-Arctic sea ice freeboard estimates from combined CryoSat-2 and Sentinel-3 satellite observations

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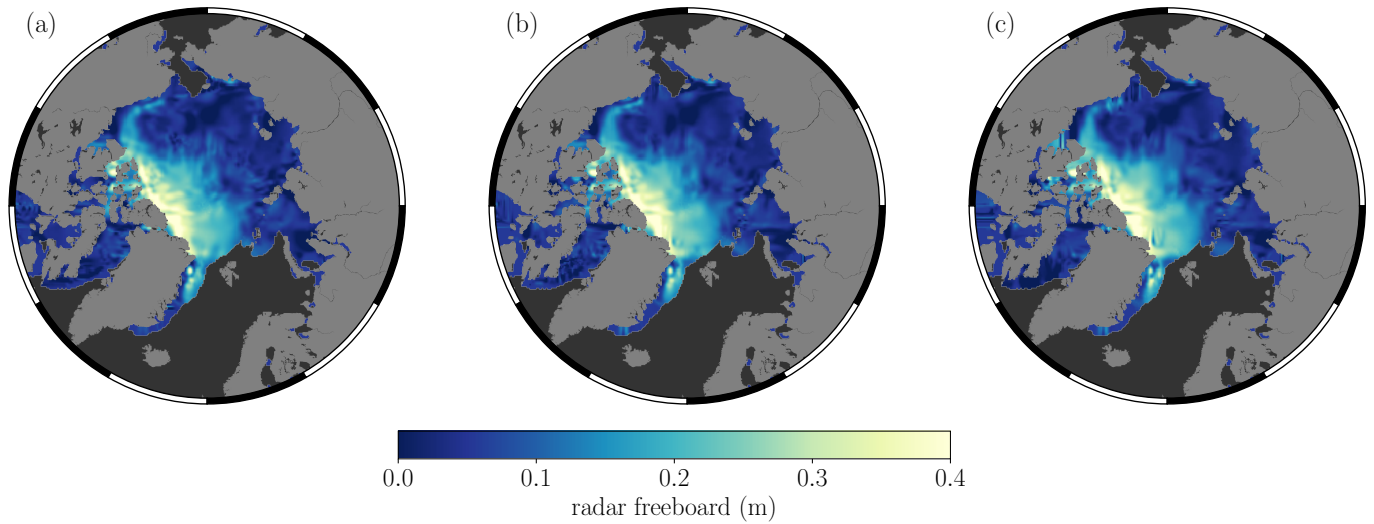


Figure S1: 25 x 25 km gridded CS2S3 radar freeboard from Gaussian Process Regression, corresponding to the 1st of December 2018. Here we vary the number of days of observations used to train the model with (a) 9 days (as per our model in the main text), (b) 5 days (+/- 2 days around the prediction day), and (c) 3 days (+/- 1 day around the prediction day). With 3 days we see linear artefacts in some regions (Beaufort and Chukchi Seas), which are suppressed (but not entirely eliminated) by increasing to 5 days.

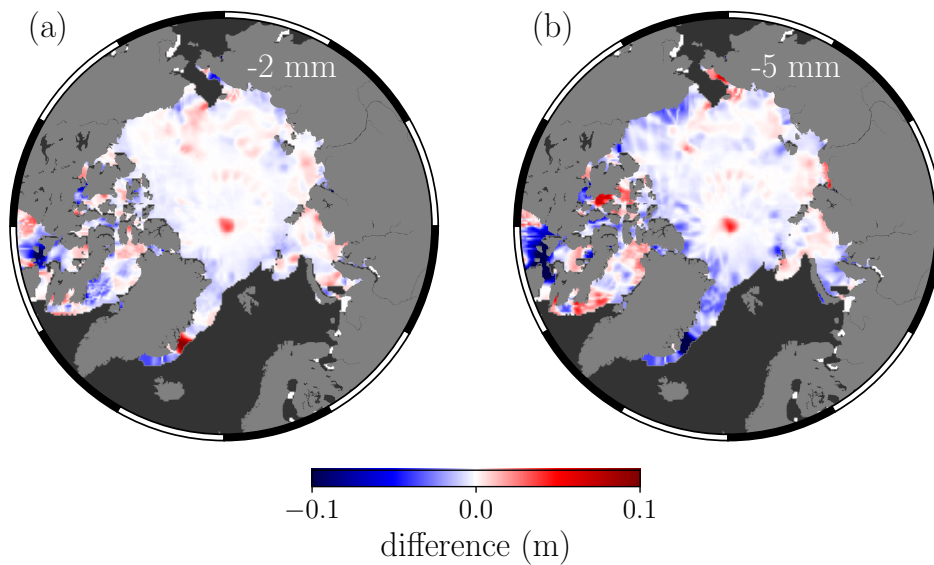


Figure S2: The difference in prediction uncertainty between the model trained with 9 days of data and (a) the model trained with 5 days of data. (b) the model trained with 3 days of data. The average difference is given for each case (-2 mm and -5 mm respectively). Negative values indicate that the uncertainty of the 9-day model is lower than either the 5- or 3-day model. Note that uncertainty at the polar hole increases with more days of training data as no observations are ever recorded there.

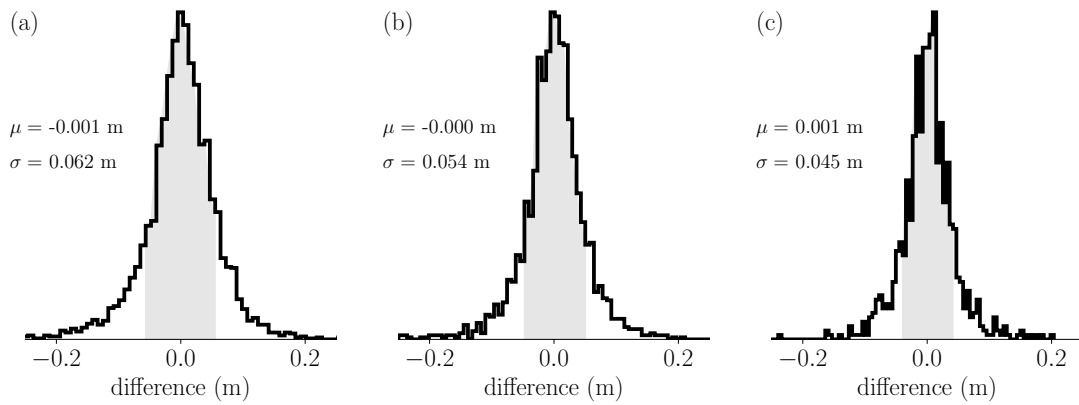


Figure S3: Training error (observations – CS2S3) for one day (1st of December 2018), for interpolations run at (a) 25 x 25 km, (b) 50 x 50 km, (c) 100 x 100 km spatial resolution. Hence the along-track CS2 and S3 observations were first gridded to each respective resolution, and pan-Arctic predictions were subsequently generated at that same resolution. Notably here, increasing or decreasing the resolution does not result in a systematic increase or decrease in the average training error.

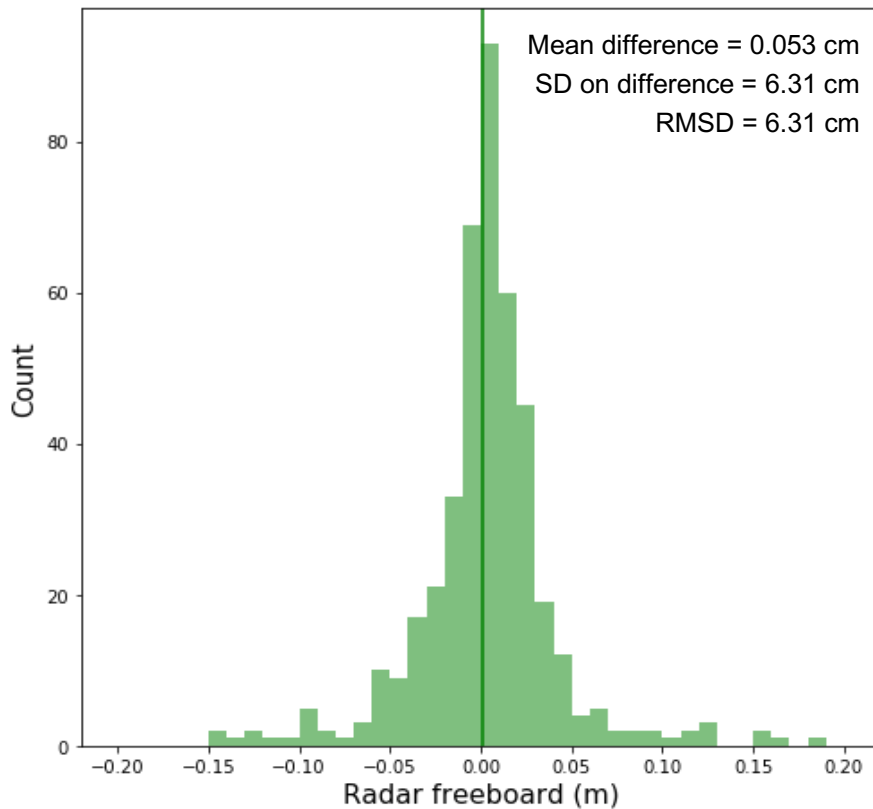


Figure S4: Histogram of S3A–S3B radar freeboard difference for tracks averaged on a 50x50km grid. The green line shows the mean difference ($=0.053\text{cm}$). A total of 35 tracks from the 14th and 15th October 2018 were gridded and compared. During this period S3A and S3B were operating in tandem mode, with S3A trailing S3B by ~ 30 seconds in the same orbit. Sea ice drift during 30 seconds can be considered negligible, therefore we can assume that S3A and S3B are observing the same sea ice, and that differences are therefore the result of noise on individual freeboard measurements (see Wingham et al. (2006) for discussion of speckle noise on CS2 measurements). The standard deviation on the difference ($\approx 6\text{cm}$) provides an estimate of the uncertainty on 50km grid-averaged S3 and CS2 radar freeboard measurements.

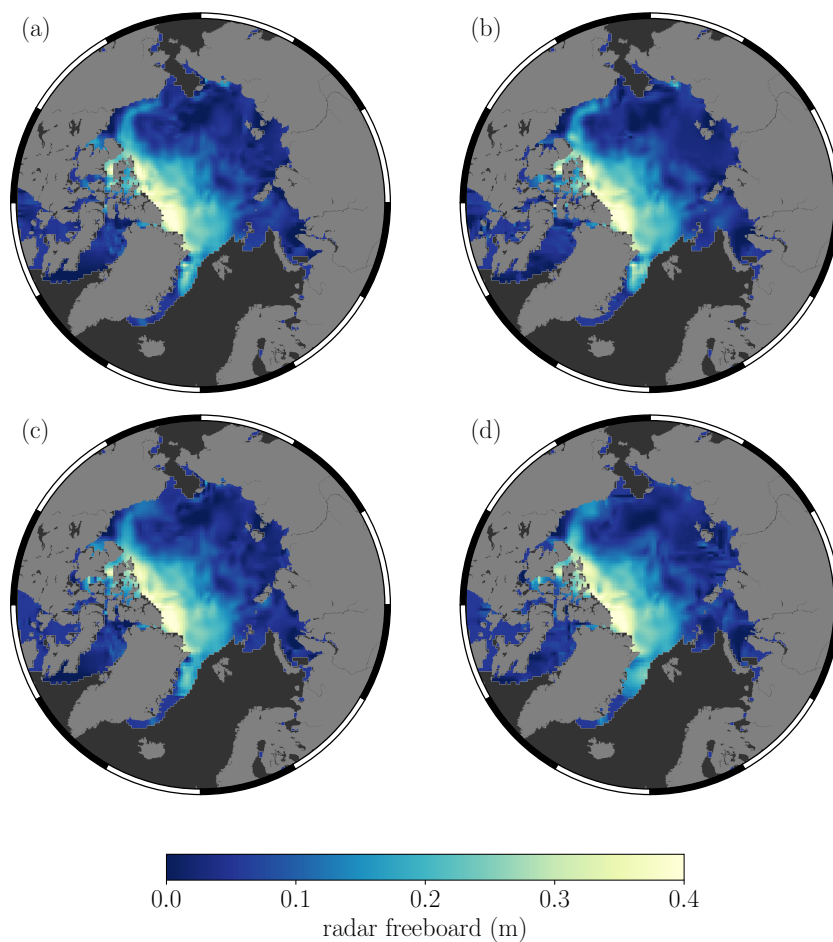


Figure S5: 50 x 50 gridded CS2S3 freeboard using 9 days of observations during training, but showing the freeboard predictions corresponding to each cross-validation experiment (Sect. 4.2 main text). (a) Using CS2, S3A and S3B during training. (b) Using CS2 and S3B during training. (c) Using CS2 and S3A during training. (d) Using only CS2 during training. Notice how features such as the ‘monkey tail’ in the Beaufort Sea are less well defined in (b), (c) and (d), than in (a). Furthermore, without any S3 data in (d) we see linear interpolation artefacts.

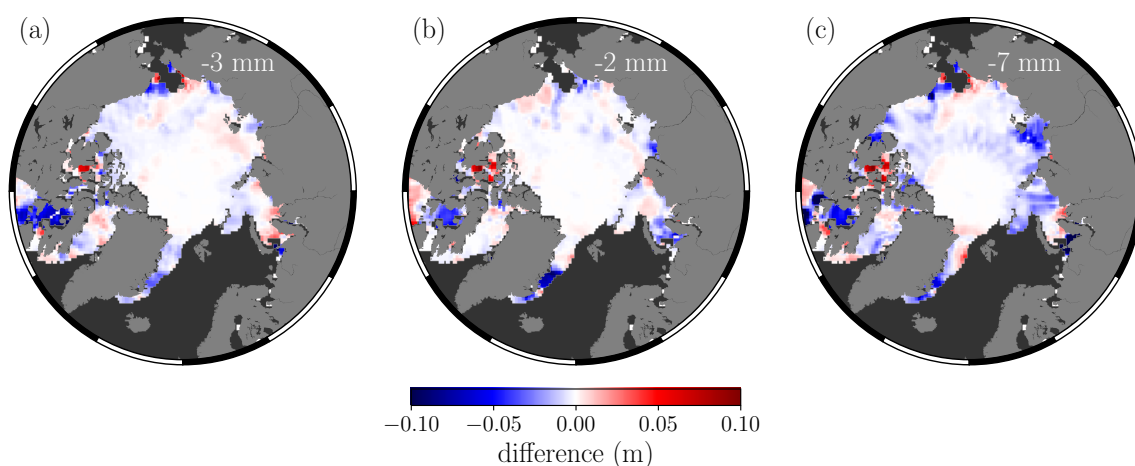


Figure S6: The difference in prediction uncertainty between the model trained with CS2, S3A, and S3B (CS2S3), and (a) the model trained with CS2 and S3B (CS2S3(-S3A)). (b) the model trained with CS2 and S3A (CS2S3(-S3B)). (c) the model trained with CS2 only (CS2S3(-S3)). The average difference is given for each case. Negative values indicate that the uncertainty of the CS2S3 model is lower.