Response to Reviewer #1

This very good paper has two main threads: (1) presentation of an efficient way to implement effects from sea ice in an operational ocean model and (2) an improved physical understanding of why so many tide gauges in the Arctic display seasonal perturbations in their tidal harmonics. Both justify publication, so I urge the editor's acceptance.

For the main results, shown in Figure 4 (total water level), I was somewhat disappointed to see how little improvement was obtained. But my enthusiasm returned when the tide results (Figure 5 and after) were presented. These results are most encouraging.

I have only a few minor comments/suggestions.

Many thanks for taking the time to review our manuscript and providing such constructive comments. Our responses to your specific comments are given below.

1: Figure 3 caption. It would be useful to have more information about the source of the landfast frequency. Simply citing the Nat. Snow and Ice Data Center is not very informative.

Agreed. We have modified the caption and included the correct citation of the data as follows:

"Observed frequency of landfast ice occurrence for December 2020 to March 2021, calculated based on the weekly fast ice extent provided by the U.S. National Ice Center (2020)."

2: Figure 4 caption (very minor). It might help readers (or browsers) to note that the missing stations are those for which only historical observations are available, and those data do not overlap with the model timeframe.

Following your suggestion, we have added the following text to the caption:

"The missing stations are those for which only historical observations are available, i.e., data do not overlap with the study period."

3: Line 19: I think a better and more comprehensive reference for Arctic Sea ice changes is a recent paper by Parkinson: https://doi.org/10.3389/frsen.2022.1021781

Thank you. We have added this good reference (Parkinson, 2022).

4: The Ray (2022) paper was published by Ocean Sciences: http://dx.doi.org/10.5194/os-18-1073-2022

Corrected.

5: For Eqns (1-4), if you are using LaTeX, you can obtain better sized parentheses and brackets by using \left and \right. See the manual.

Corrected. It looks much better. Thanks.

6: The discussion in the Supplement of poor results at Nome, Alaska, is interesting, in part because NOAA has noted its water level predictions for Nome are the worst of any U.S. tide gauge. See: https://tidesandcurrents.noaa.gov/pdf/Tide_Prediction_Error_for_the_United_States_Coastline.pdf.

The tides at Nome are small, and non-tidal variability is large, according to a spectrum of tidal residuals (http://dx.doi.org/10.1357/002224017821836761, Figure 3), but that does not explain why O1, K1 display such large annual perturbations while the semidiurnal tides do not. A mystery, although it could be related to discharge, as the authors speculate.

This is a very good point, and we realize that the nonlinear tide-surge interaction could also be an important contributor to the large observed modulations of O1, K1 at Nome. It is also interesting that diurnal tides display large annual perturbations while semidiurnal tides do not. We modified the Supplement to include a brief discussion:

"Egbert and Ray (2017) showed that the non-tidal variability at Nome is large compared to tides, implying potential effects of the nonlinear tide-surge interaction (TSI). We speculate that the observed large modulations of O1, K1 are affected by both sea ice and the TSI. Both are not well captured locally (the model underestimates the amplitudes of O1 and K1, by up to half in ice-free months). It is also interesting to note that in contrast, the semidiurnal tides do not display large modulations. This may be attributed in part to the more complex semidiurnal amphidrome systems over this region (see the left panel of Fig. 9 in the main text), characterized with smaller wavelength than diurnal tides."

New references mentioned in the response letter:

Egbert, G. D., & Ray, R. D.: 'Tidal prediction' in The Sea: The Science of Ocean Prediction. *Journal of Marine Research*, *75*(3), 189-237, 2017.

Parkinson, C. L.: Arctic Sea Ice Coverage from 43 Years of Satellite Passive-Microwave Observations. *Frontiers in Remote Sensing*, 94, 2022.

U.S. National Ice Center: U.S. National Ice Center Arctic and Antarctic Sea Ice Concentration and Climatologies in Gridded Format, Version 1. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/46cc-3952. 2020.