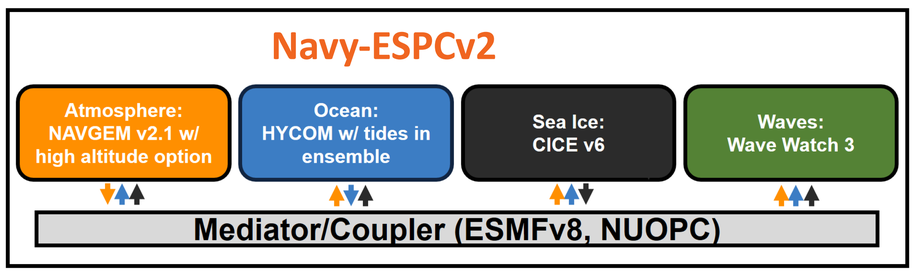
SYMPOSIUM OP'24 ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Theme #3: Polar Ocean/Sea Ice

U.S. NAVAL RESEARCH LABORATORY

Recent Updates in Sea Ice Modeling within U.S. Navy Earth System Prediction Capability (ESPC) model

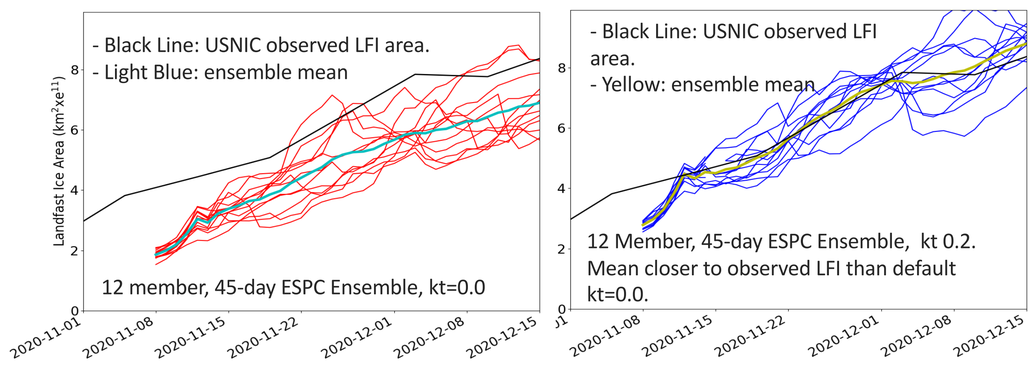
David Hebert[1], Rick Allard[1], Elizabeth Douglass[1], Jackie May[1], Joe Metzger[1], Gleb Panteleev[1], Michael Phelps[2], Tamara Townsend[1]
[1]U.S. Naval Research Laboratory, Stennis Space Center, MS,
[2]Peraton, Inc., Stennis Space Center, MS, U.S.A.



Navy ESPC is a coupled modeling system from the bottom of the ocean to the top of the atmosphere. Data is exchanged through ESMF coupler. Arrows show component coupling items and directions. Currently Waves is one-way coupled – it receives data from other models but does not export data yet.

Landfast Ice (LFI)

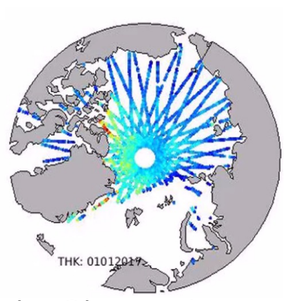
LandFast Ice (LFI) is ice that is attached to coast or reaches the seafloor. These connections cause the ice to remain stationary. CICE Version 6 added capability of model Land Fast Ice following Lemieux et al. 2015, 2016. This parameterization is controlled by rheological parameter 'k1', 'k2' and tensile strength 'kt'. In this study LFI is defined where ice velocity < 0.5 mm/s for 7 days. In the plot below, setting kt = 0.2 improved the modeled LFI compared to U.S. National Ice Center (USNIC) observed LFI (Black line).



Assimilate CryoSat-2 (CS2) ice thickness

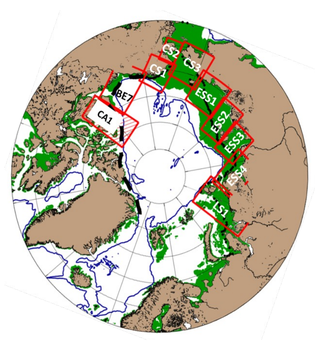
Currently we only assimilate ice concentration analysis, not ice thickness. Here we test assimilating CryoSat-2 ice thickness observations.

- Synthetic Aperture Interferometric Radar Altimeter
- Repeat cycle: 369 days
  - 28-day subcycle
- Penetrates snow, measures ice freeboard
- Only available Oct-May
  - Has trouble with melt ponds
- Minimum thickness obs 0.3 m
- Only where ice concentration >= 75%
- Available in 2-day, 14-day, and 28-day observations.
- Near-real-time 2-day obs available from Centre for Polar Observations and Modeling at University College London. (Tilling et al. 2016)

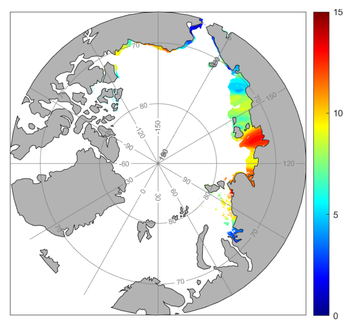


Spatially varying parameter k_1

The parameters k_1 and k_2 are controlled by geological factors and coastline configuration (Nikishin et al. 2019). This suggests LFI parameterization can be improved with spatially varying parameters. Here spatially varying parameter k_1 (Allard et al. 2023) is generated by optimizing an uncoupled, standalone CICE model over 10 arctic subregions (Left plot). The right plot show the resulting values of k1, with the highest values in the East Siberian Sea (ESS).



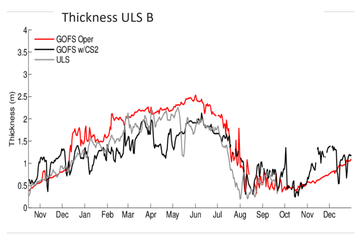
Subregions studied



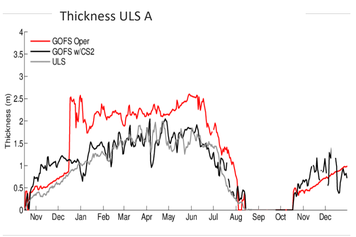
Spatially Varying k1

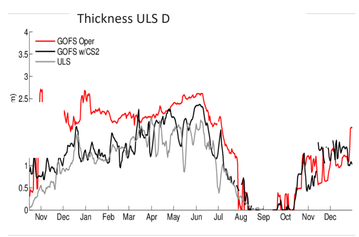
CS2 Assimilation Test

- Tested in Ocean/CICE coupled system.
- Oct 16, 2017 – Dec 31, 2018.
- Reinitialized from CS2 28-day observation to reduce initial shock. Then assimilated 2-day observations.
- No obs in summer, May – Sept.
- Did not reinitialize Oct 2018 after summer with no observations.
- Results compared to Woods Hole Oceanographic Institute (WHOI) Beaufort Gyre Upward Looking Sonar (ULS).

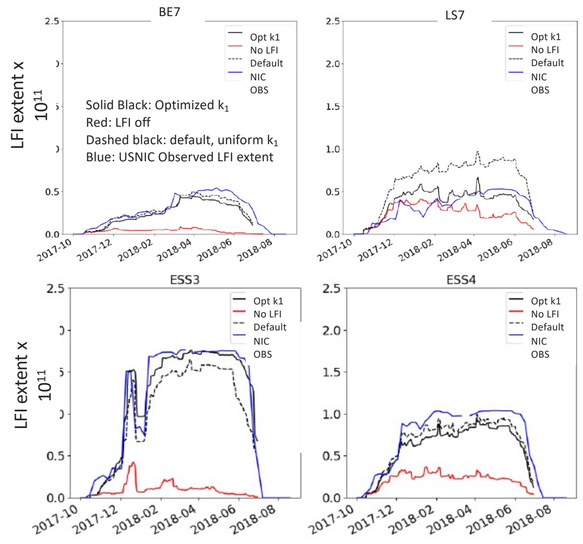


Color Legend
without CryoSat-2
with CryoSat-2
ULS





Assimilating CryoSat-2 reduced model Root Mean Square Error (RMSE) by 55%, 7%, 63% at Mooring A, B, D respectively.



Landfast ice extent for several subregions. In most regions like Laptev Sea (LS7), East Siberian Sea (ESS3) shown here, the LFI with spatially varying, optimized k_1 (solid black) is closer to the NIC observation (blue line) than the uniform, default k_1 (dashed black). In some regions such as ESS4 and the Beaufort Sea (BE7), the LFI with uniform k_1 is closer to the USNIC observations.

We plan to test spatially varying k_1 within fully coupled ESPC.

References

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Lemieux, J.-F., L. B.Tremblay, F. Dupont, M. Plante, G. C. Smith and D. Dumont (2015): A basal stress parameterization for modeling landfast ice, J. Geophys. Res. Oceans, 120, doi:10.1002/2014JC010678.

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Nikishin, A.M., Startseva, K.F., Verzhbitsky, V.E. et al. Sedimentary Basins of the East Siberian Sea and the Chukchi Sea and the Adjacent Area of the Amerasia Basin: Seismic Stratigraphy and Stages of Geological History. Geotecton. 53, 635–657 (2019). https://doi.org/10.1134/S0016852119060104.

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