Supporting Information for "Bayesian Unsupervised Machine Learning Approach to Segment Arctic Sea Ice from SMOS"

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Introduction

The choice of the appropriate number of classes is justified from the distribution of input features and the class separability. Figure F1 shows the marginal distribution of the polarization ratio (PR) at an incidence angle of 56° at 4 particular dates including the end of summer melt and the early freeze-up. PR distributions are shown for segmentation with 2 and 3 classes, respectively. During late summer melt until sea ice minimum (September 10, 2016), the choice of two classes was expected from the shape of the PR distribution. With the beginning of the freeze-up period, higher PR values become more frequent and an additional class is expected. Class separability is indicated by the Geometric Separability Index (GSI) and was obtained subsequent to segmentation. From the segmentation step at September 16, 2016 onwards, segmentation with a choice of 3 classes results in higher separability.

The classes were labeled according to the sea ice thickness estimates of the available SMOS-SIT product (Tian-Kunze et al., 2014). Figure F2 visualizes the latent field result in comparison to SMOS-SIT maps at the segmentation step intervals October 19-23, November 8-12, and December 23-27, 2016. Class 0 predominately contains consolidated thick ice beyond the sensitivity range of L-band $>\sim 0.6\,\mathrm{m}$ (sensor saturation), class 1 refers to a transition zone of multiple thickness and types, and class 2 can be attributed to newly-formed thin ice.

Table T1 summarizes the obtained class mean values and standard deviations, averaged over the freeze-up period from October 15 to December 31, 2016. At each segmentation step interval, SIT mean values for each class are calculated according to the spatial patterns of the latent field result. The obtained values at each segmentation step are then averaged over the freeze-up. The classes 0 and 2 show less variation and form stable clusters along the entire period, whereas class 1 contains higher variation. All three classes show sufficient separability along the entire period.

Caption Animation A1 Animation of the spatial patterns of the latent field result in physical space at each segmentation step interval from September 1 to December 31, 2016, including the distribution of the PR at 56° incidence angle.

References

Tian-Kunze, X., Kaleschke, L., Maaß, N., Mäkynen, M., Serra, N., Drusch, M., & Krumpen, T. (2014). Smos-derived thin sea ice thickness: algorithm baseline, product specifications and initial verification. *The Cryosphere*, *8*, 997–1018.

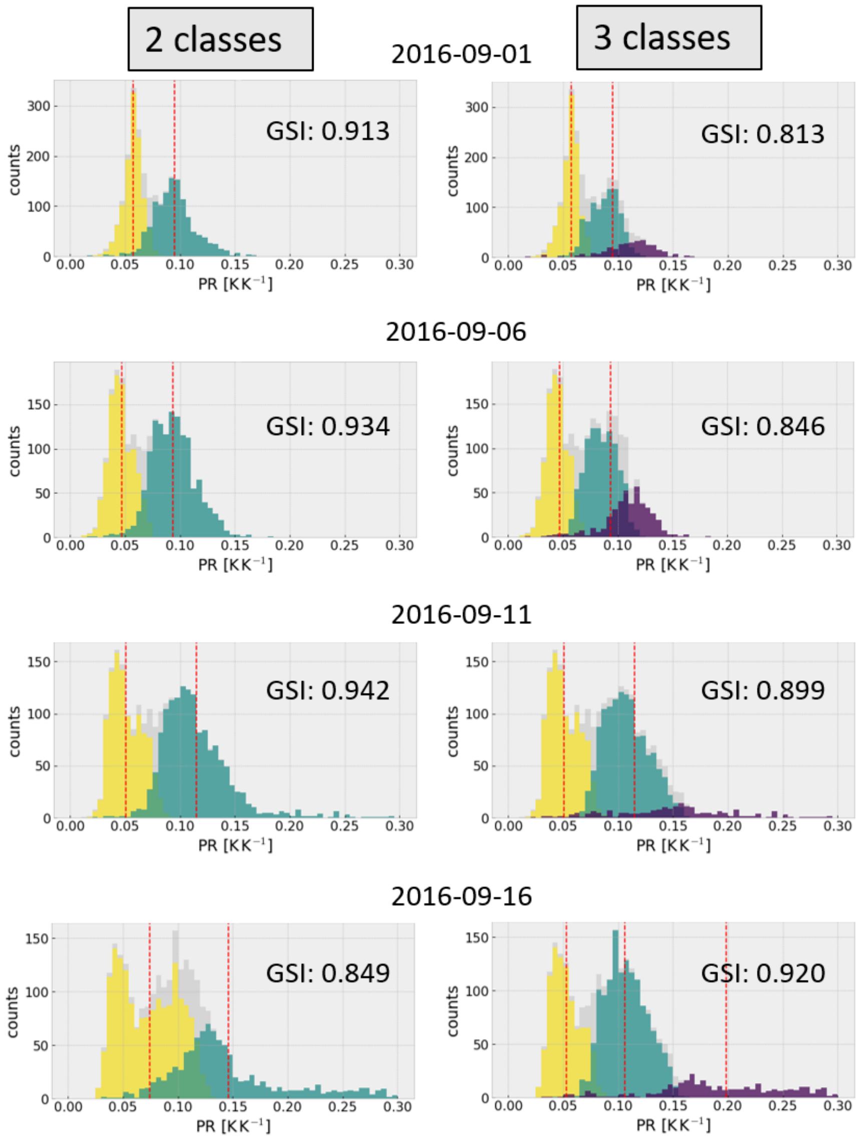

Figure F1. Distribution of PR values at 56° incidence angle for late summer melt and early freeze up from September 1 to September 16, 2016, including the indicated class membership and global separability (GSI), obtained for segmentation with 2 classes (left-hand side) and 3 classes (right-hand side), respectively.

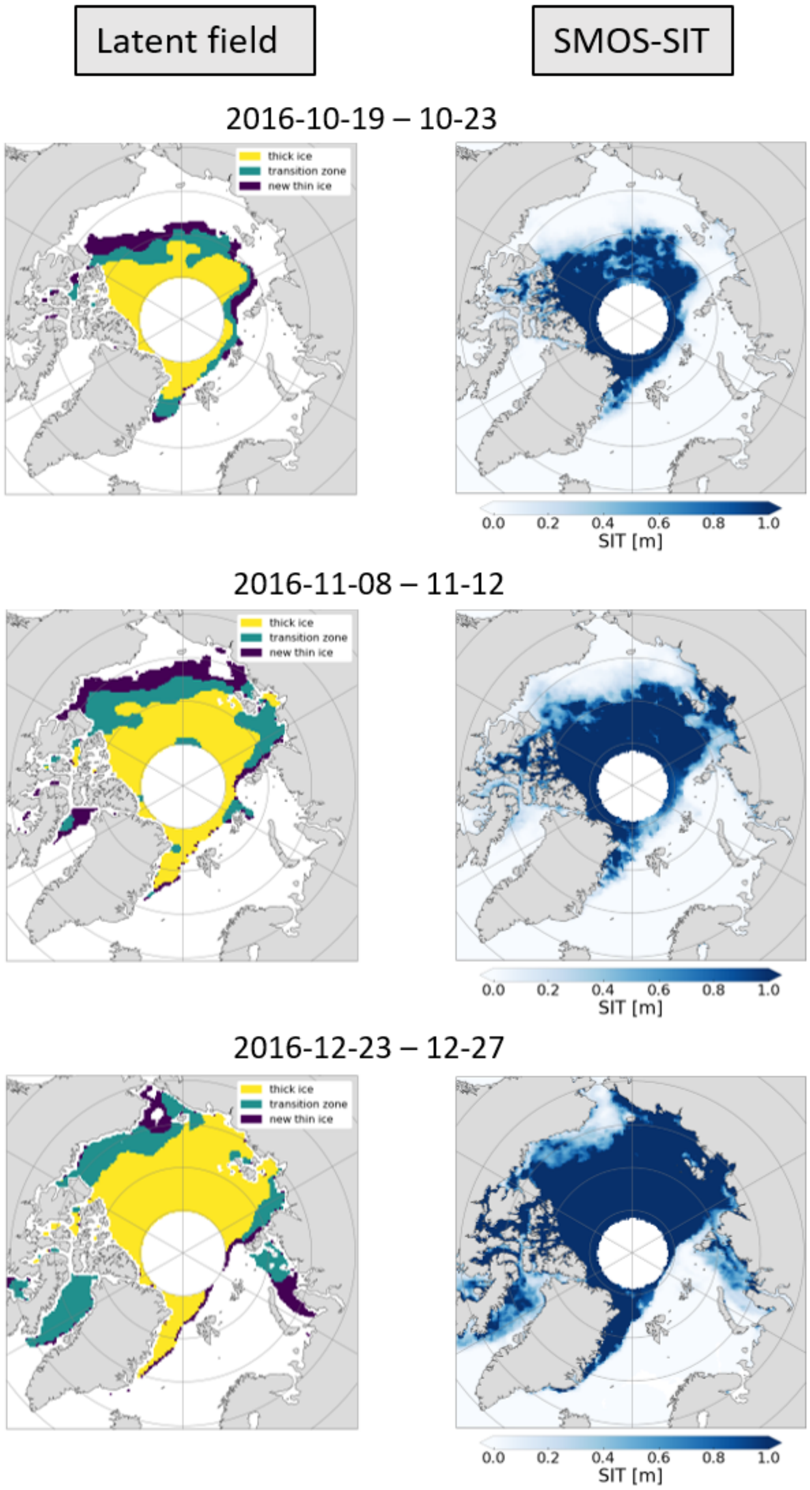

Figure F2. Comparison of the obtained latent field result with SIT maps of the SMOS-SIT product, averaged over the corresponding segmentation period (5-day interval).

Table T1. Summary of the temporal evolution of classes, evaluated within the freeze-up period from October 15 to December 31, 2016. Comparison of PR cluster mean values and standard deviations (StDev) at 56° incidence angle, including global separability (GSI), with the SMOS-SIT product.

Class	Label	PR mean	PR StDev	GSI	SMOS-SIT [m]
0	Thick ice	0.061 ± 0.005	0.014 ± 0.004	0.95 ± 0.02	1.24 ± 0.010
1	Transition zone	0.112 ± 0.012	0.028 ± 0.006	0.83 ± 0.04	0.54 ± 0.24
2	New thin ice	0.187 ± 0.03	0.048 ± 0.009	0.83 ± 0.08	0.13 ± 0.07