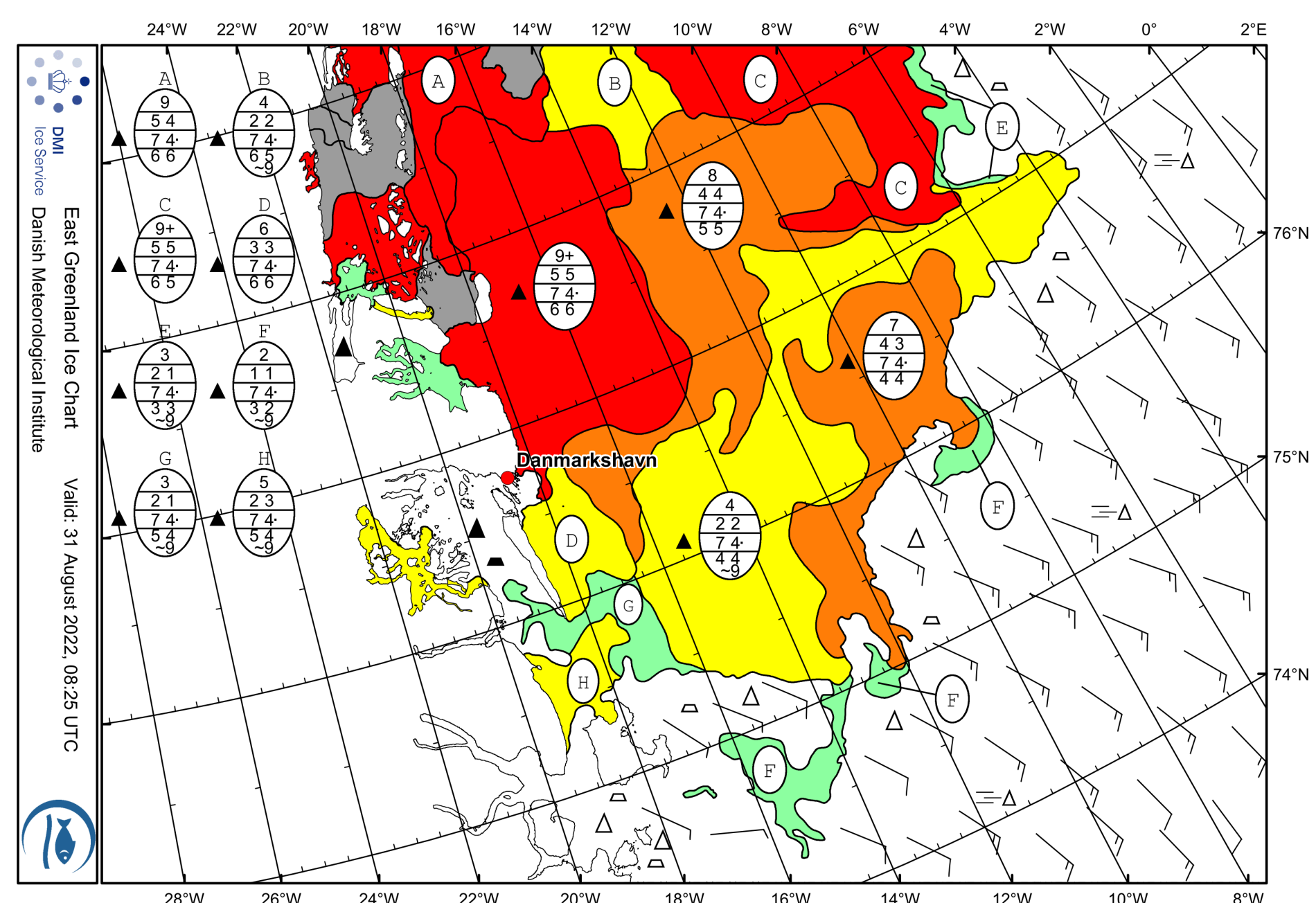
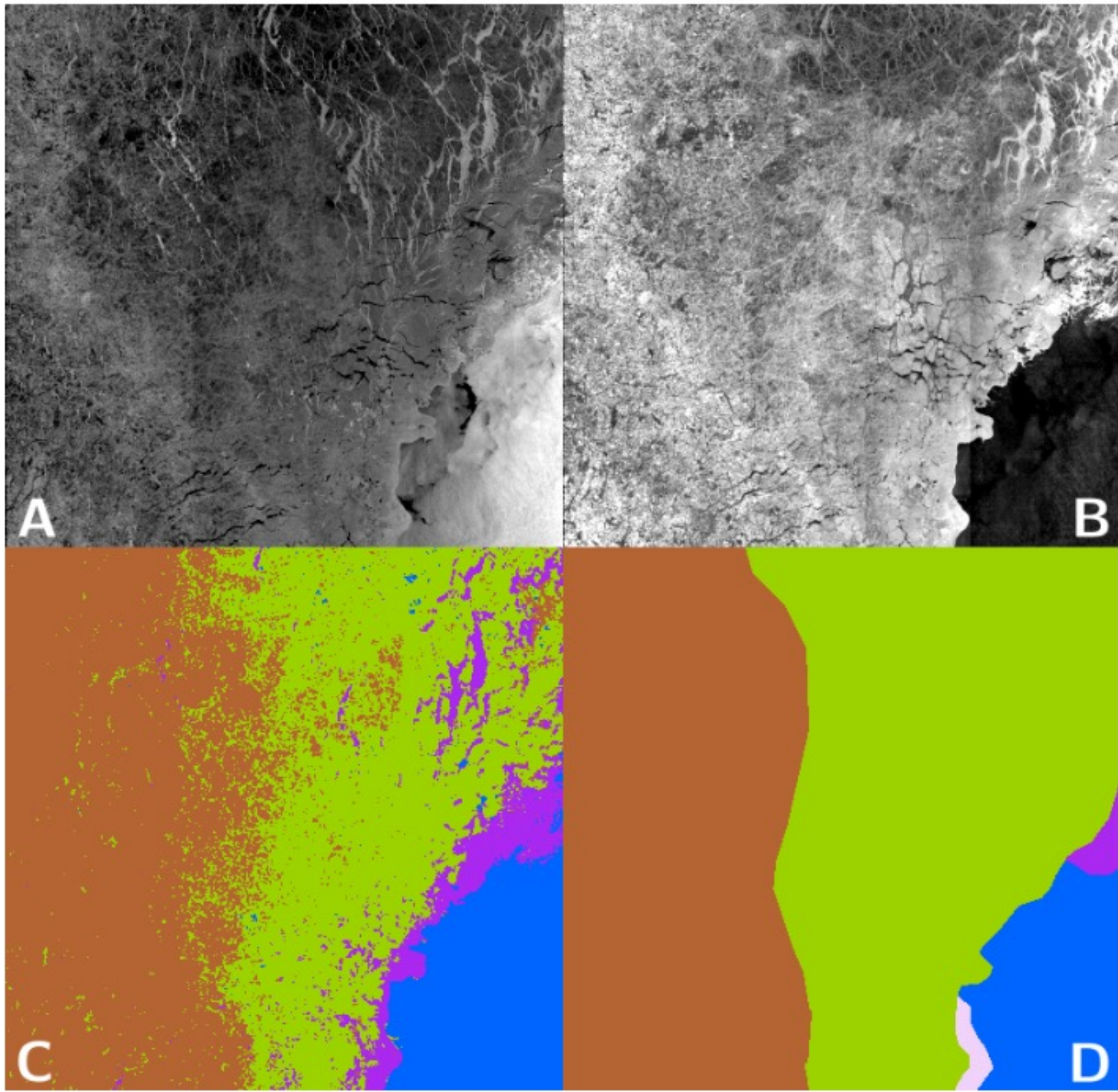


Suggestions for improving automatic sea ice charting with synthetic aperture data

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An ice chart is a very detailed map of sea ice conditions manually drawn by experts in operational ice centers around the Arctic (e.g., Danish Meteorological Institute, above). Ice charts show concentration, age and form of ice.



		True label			
		Ice free	Young ice	First-year ice	Old ice
Predicted label	Ice free	0.97	0.01	0.01	0.00
	Young ice	0.00	0.85	0.10	0.01
	First-year ice	0.03	0.14	0.86	0.05
	Old ice	0.00	0.01	0.04	0.94

An automatic algorithm has been proposed for classification of ice types on SAR imagery using convolutional neural networks. The algorithm has high accuracy (winter estimates), provides more details than conventional ice charts and requires fewer human resources to be generated. However, training of the algorithm is performed on ice charts, which can be inaccurate.

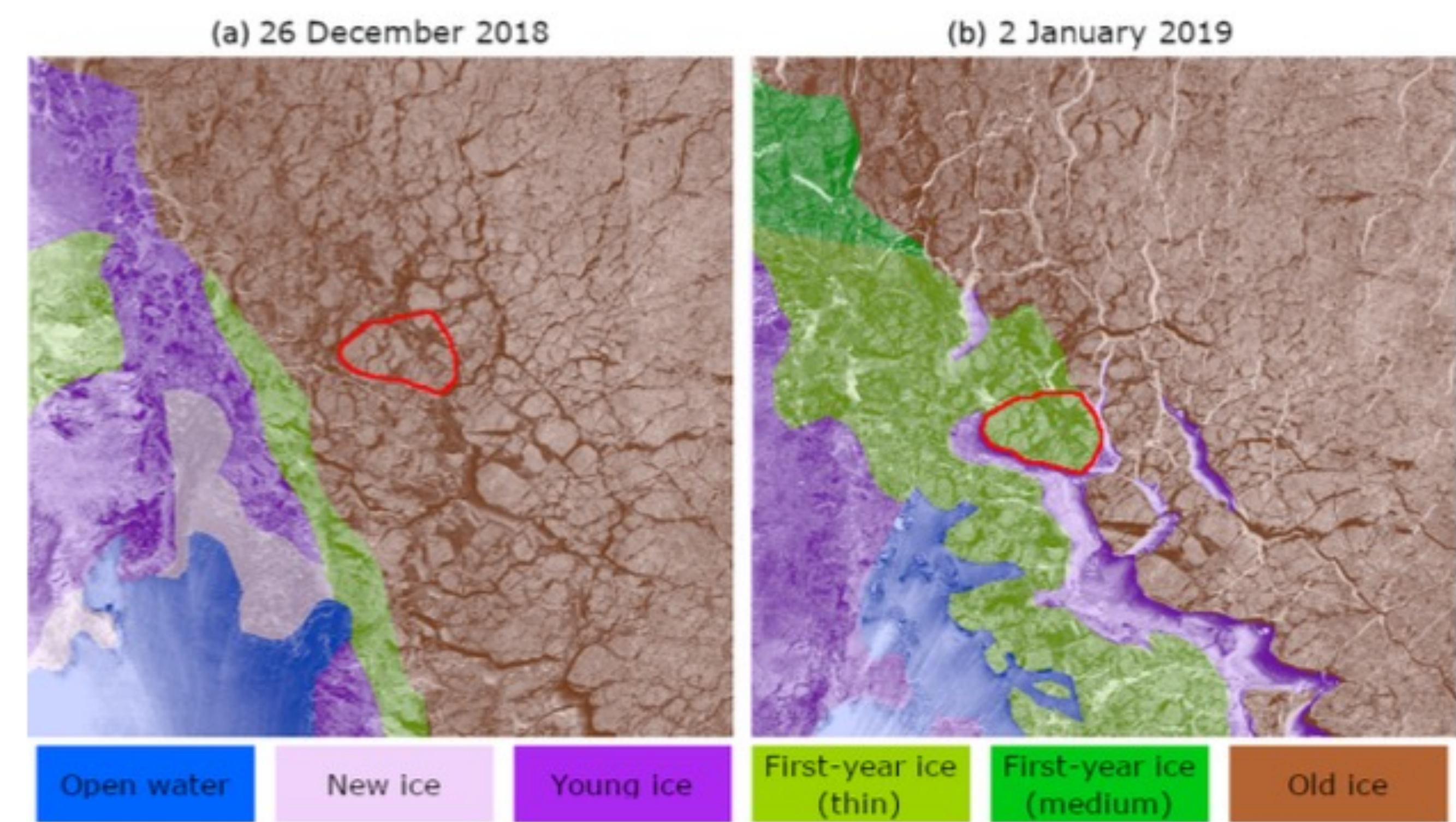
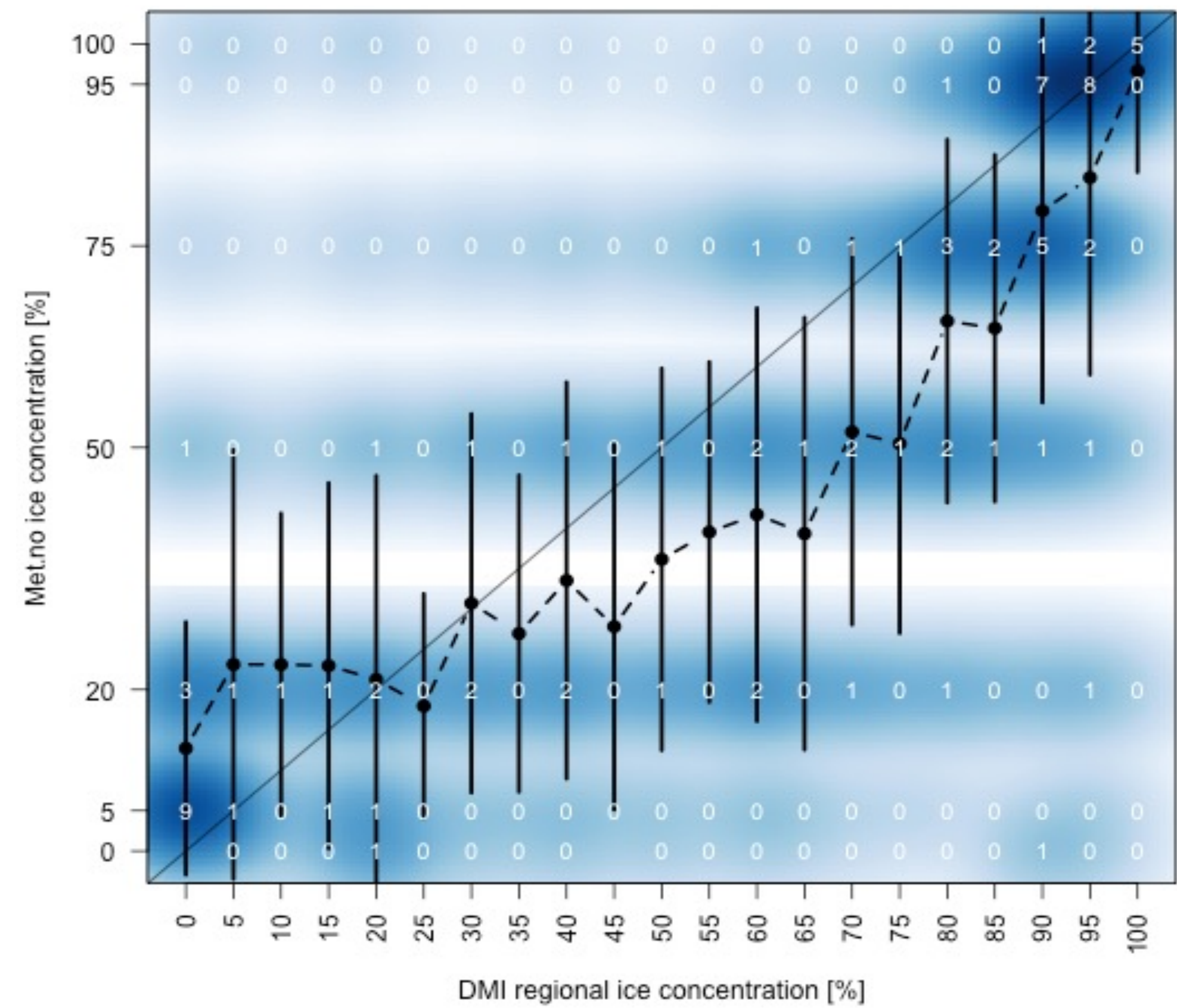


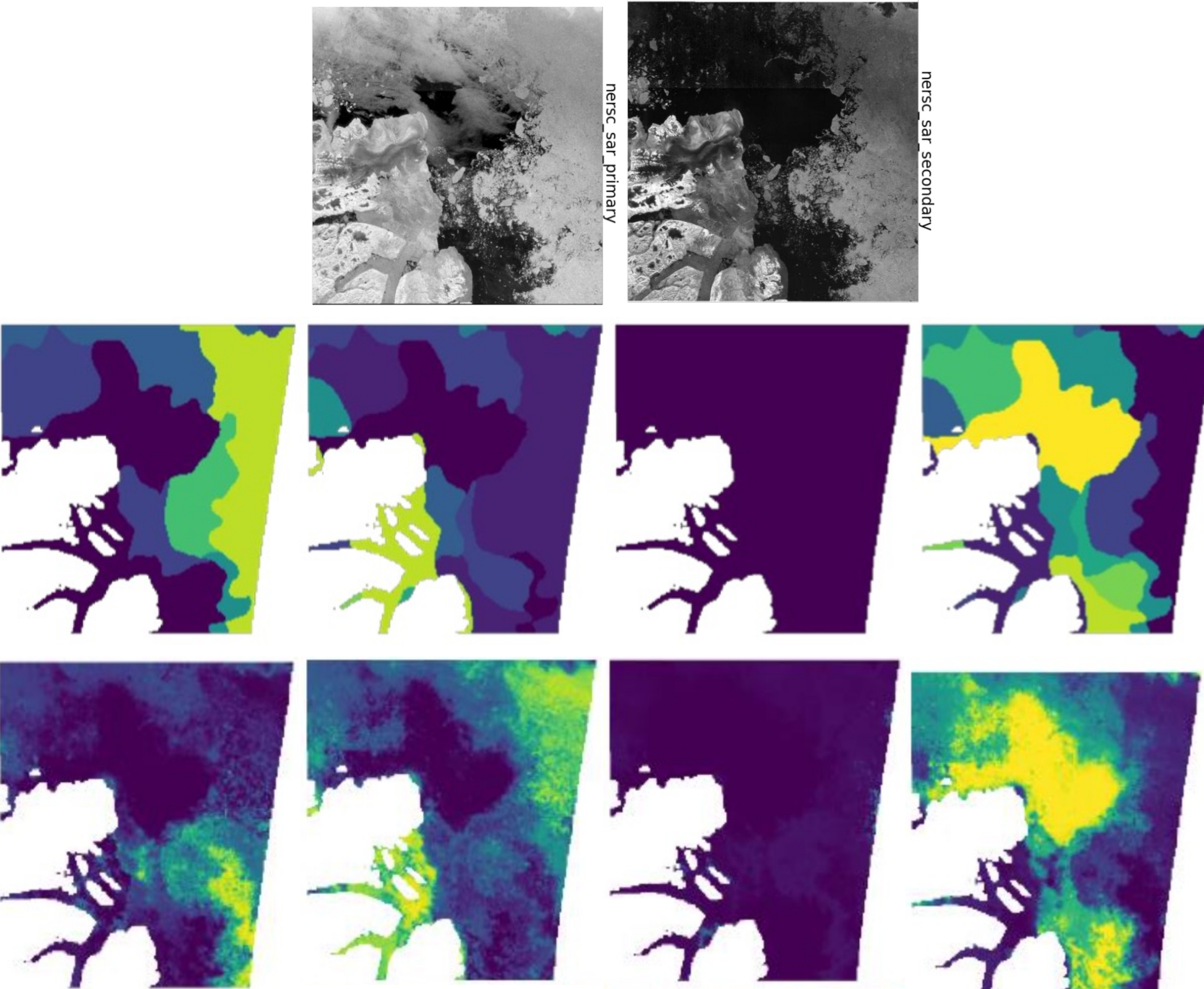
Figure 11. An example of the inconsistency of the ice charts. Note that the SoD labels and colours are of an original NIC ice chart, while those in Figs. 7 and 8 are of a simplified version as described in Sect. 2.2.1. The SoDs from the NIC ice charts on different dates (26 December 2018 and 2 January 2019) are superimposed on the Sentinel-1 backscattering image of the corresponding dates. The same ice floe (red outline) is classified differently in each ice chart (old ice in **a** and first-year ice in **b**) despite the similarity in the SAR backscattering images. Source credits: U.S. National Ice Center (colours) and European Space Agency (background).



Comparison of sea ice concentration from ice charts provided by experts in DMI and Norwegian Meteorological Institute. Despite good overall agreement, some significant deviations in estimation of concentration occur for mid- and low-ranges of concentrations.

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A new algorithm was proposed for deriving not only dominant age of sea ice but also fractions of various ice components (MYI, FYI, YI, WATER) by combining SAR and AMSR2 on input.

Pearson correlation Matrix					
True Values	Water	YI	FYI	MYI	
	Water	0.980	-0.405	-0.781	-0.456
	YI	-0.432	0.938	0.160	-0.105
	FYI	-0.776	0.106	0.959	0.027
	MYI	-0.491	-0.082	0.055	0.936
Predicted Values					

It was shown that the accuracy of concentration prediction for each fraction is quite high (~95% on average) and up to 13 combinations of age and form of sea ice can be derived from SAR and AMSR2 data.

Lower classification accuracies are reported in several studies (80% in Zakhvatkina et al., 2013; 91.7% in Liu et al., 2015; 87.2% in Aldenhoff et al., 2018) which use manually classified ice maps as training and validation reference. In addition, an overall bias may exist since the public ice charts are produced in the interest of marine safety (Karvonen et al., 2015).

It appears feasible that usage of independent objective data from other types of satellite sensors, such as, e.g., CryoSat-2 or IceSat-2 altimeters, may help circumvent the problem of subjective and inconsistent judgments by ice experts.