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Regional scale albedo of first year Arctic drift ice during summer melt estimated from synthesis of in situ measurements and airborne imagery

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The paper presents the results of analysis of the radiative properties of first year sea ice in advanced stages of melt. The presented technique is based on the upscaling in situ point measurements of surface albedo to the regional (150 km) spatial scale using aerial photographs of sea ice captured by a helicopter borne camera setup. The sea ice imagery as well as in situ snow and ice data were collected during the eight day ICE12 drift experiment carried out by the Norwegian Polar Institute in the Arctic north of Svalbard at 83.5 N during 27 July-03 August 2012. In total some 100 ground albedo measurements were made on melting sea ice in locations representative of the four main types of sea ice surface identified using the discriminant analysis -based classification technique. Some 11000 images from a total of six ice survey flights adding up to some 770 km of flight tracks covering about 28 km2 of sea ice surface were classified to yield the along-track distributions of four major surface classes: bare ice, dark melt ponds, bright melt ponds and open water. Results demonstrated a relative homogeneity of sea ice cover in the study area allowing for upscaling the local optical measurements to the regional scale. For the typical 10% open water fraction and 25% melt pond coverage, with a ratio of dark to bright ponds of 2 identified from selected images, the aggregate scale surface albedo of the area was estimated to be 0.42(0.40;0.44). The confidence intervals on the estimate were derived using the moving block bootstrap approach applied to the sequences of classified sea ice images and albedo of the four surface classes treated as random variables. Uncertainty in the mean estimates of local albedo from in situ measurements contributed some 65% to the variance of the estimated regional albedo with the remaining variance to be associated with the spatial inhomogeneity of sea ice cover. The results of the study are of relevance for the modeling of sea ice processes in climate simulations. It particularly concerns the period of summer melt when the optical properties of sea ice undergo substantial changes which the existing sea ice models experience most difficulties to accurately reproduce. That phase of a season is especially crucial for climate and ecosystem processes in the polar regions.