INFLUENCE OF MELT PONDS ON MICROWAVE SENSORS' SEA ICE CONCENTRATION RETRIEVAL ALGORITHMS

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1. INTRODUCTION

In boreal summer, melt ponds are a common feature on Arctic sea ice and they can cover up to 50 to 60 % of the sea ice area [1, 2]. On a flat topography of first-year ice and in an early melt stage the melt pond fraction can even rise up to 90 % [3]. Melting, caused by shortwave insolation and surface air temperatures above the freezing point during summer, results in the development of melt ponds on the sea ice surface and a decrease of the surface albedo from approximately 0.8 to 0.5 which excites additional heat uptake [4]. Additionally, the appearance of melting sea ice, especially of melt ponds on the sea ice surface, causes uncertainties in the results of sea ice concentration retrievals based on passive microwave sensors like SSM/I (Special Sensor Microwave Imager) or AMSR-E (Advanced Microwave Scanning Radiometer for EOS) [5, 6, 7]. These sea ice concentration retrievals have been used since more than three decades, are well-investigated, and reliable on a large scale. Nevertheless, the influence of melting sea ice, especially of melt ponds on the sea ice surface, still causes uncertainties in all retrieval algorithms [5, 6, 7].

In this paper we analyze the impact of melt ponds on the from passive microwave sensors retrieved sea ice concentrations using melt pond fractions derived from MODIS satellite data.

2. MODIS MELT POND DATA SET

Due to different spectral properties of snow, ice, and water, the fractional coverage of these distinct surface types can be derived from multispectral sensors like MODIS using a spectral unmixing algorithm [8, 9]. To comply with the physical restrictions, we implement a side condition to constrain the interval of the solution between zero and one. Solving of the algorithm is performed using a multilayer perceptron (MLP) to reduce computational costs.

Arctic-wide melt pond fractions and sea ice concentrations are derived from the weekly level 3 MODIS surface reflectance product (MOD09A1) for the melt seasons from 2000-2011 [9].

3. MELT PONDS INFLUENCING THE MICROWAVE SEA ICE CONCENTRATION RETRIEVALS

With MODIS melt pond fractions, we have now the ability to compare melting features directly with sea ice concentrations. Additionally, the obtained MODIS sea ice concentrations are useful to estimate uncertainties in microwave retrievals.

In this context, we perform a case study in the Canadian Archipelago on the data set of 18 June 2011. The study area is a 250 km x 100 km region around the coordinate 72° N and 110° W (see Figure 1). On the flat level ice in this region occur in June very high relative melt pond fractions with values up to 70% (see Figure 1 bottom).

Figure 1 displays in the first three images sea ice concentration from AMSR-E sensor, calculated with the ASI algorithm [10], the NASA-Team 2 (NT2) algorithm [11], and the Bootstrap (BT) algorithm [12] for the area of the Canadian Archipelago. The mean sea ice concentration ranges in all three cases from 64% - 72%. The fourth image displays MODIS sea ice concentration. Compared to the sea ice concentration of 93% retrieved from the MODIS data, all microwave algorithms underestimate the sea ice concentration by around 20-30%. It is evident, that the areas containing high melt pond fractions (>40%) exhibit low sea ice concentrations for the microwave retrieved results. The MODIS sea ice concentrations show an homogeneous distribution around 93%.

4. CONCLUSION

The introduced MODIS melt pond fractions and it's corresponding sea ice concentration data set are valuable sources for multiple applications in Climate sciences. Knowledge about the occurrence of melt ponds is essential to properly document the energy balance on the sea ice surface during summer. Additionally, melt pond fractions can be used to quantify the uncertainties in sea ice concentration data derived from passive microwave imagery. As shown in Figure 1, the MODIS melt pond fractions can be used to estimate the influence of melt ponds on the sea ice concentration determination from microwave sensors like AMSR-E. In this example, all AMSR-E algorithms are clearly underestimating MODIS sea ice concentration by around 20-30%. In the final paper a detailed analysis of the uncertainties caused by melt ponds and an assessment of the different sea ice concentration retrieval methods will be given.

The MODIS melt pond data set will be provided through the Integrated Climate Data Center (ICDC, http://icdc.zmaw.de/cryosphere.html).

5. REFERENCES

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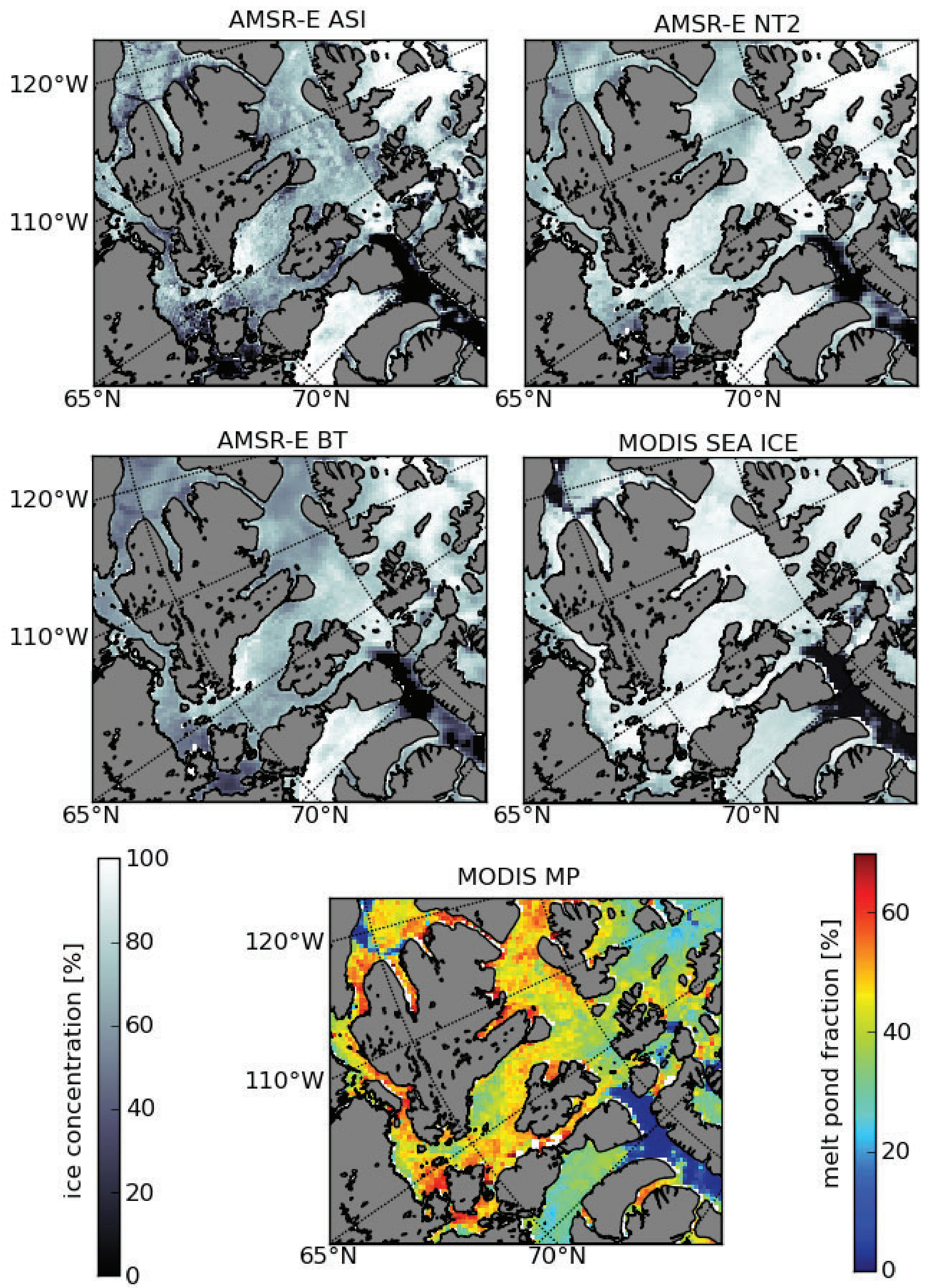

Fig. 1. Comparison of AMSR-E ASI (top left), AMSR-E NASA-Team 2 (top right), AMSR-E Bootstrap (middle left), and MODIS (middle right) sea ice concentrations. In the bottom MODIS melt pond fraction is displayed. All images are from June 18, 2011.