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Spring melt ponds drive Arctic September ice at past, present and future climates in coupled climate simulation

David Schroeder (1), Danny Feltham (1), Jamie Rae (2), Daniela Flocco (1), Jeff Ridley (2), and Edd Blockley (2)

(1) University of Reading, Centre for Polar Observation and Modelling, Department of Meteorology, Reading, United Kingdom (d.schroeder@reading.ac.uk), (2) Polar Climate Group, Met Office, Hadley Centre, Exeter, United Kingdom

Stand-alone sea ice simulations with a physical based melt pond model reveal a strong correlation between the simulated spring pond fraction and the observed as well as simulated September sea ice extent for the period 1979 to 2014. This is explained by a positive feedback mechanism: more ponds reduce the albedo; a lower albedo causes more melting; more melting increases pond fraction. This feedback process is a potential reason for the acceleration of Arctic sea ice decrease in the last decade and the failure of many climate models (without an implicit pond model) to simulate the observed decrease.

We implemented the Los Alamos sea ice model CICE 5 including our physical based melt pond model into the latest version of the Hadley Centre coupled climate model, HadGEM3. The model surface shortwave radiation scheme has been adjusted to account for pond fraction and depth. We performed three 55-year HadGEM3 simulations with constant external forcing for the years 1985, 2010 and 2035. In all three simulations we find a strong correlation between the April/May pond fraction and the September sea ice extent with correlation coefficients R1985 = -0.86, R2010 = -0.83 and R2035 = -0.79. Based on the correlation we can perform forecasts with remarkable skill values of S1985 = 0.50, S2010 = 0.36 and S2035 = 0.40. We calculate the skill as S = 1 – σferr2/ σref2, where σref2 is the variance of the de-trended climatology and σferr2 the forecast error variance. Altogether our three simulations cover a large range of September sea ice extent from maximum values of 8.5 million km2 for the 1985 run down to 1.5 million km2 for the 2035 run. We demonstrate that spring melt ponds are an important driver for summer ice melt and the consequent minimum ice extent for current and future climate conditions.