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On the role of turbulent heat exchange at the ocean-air interface in the fall on the state of the Arctic sea ice

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Arctic sea ice decline has accelerated after 2007, leading to wider ice free areas for a longer time intervals in summer. Exposure of the open water surface enhances ocean-air energy exchange, allowing from one side, extra heat to be accumulated in the upper ocean in summer and, from the other, massive ice growth in winter. These competitive processes are not simple and straightforward, because thermodynamic forcing at the ocean-air interface is complemented by thermodynamic forcing in the underlying ocean, in the overlaying atmosphere, and by direct dynamical forcing in both environments. In this study we focused on the specific features of ocean-air interaction in the Laptev Sea in summer on the basis of recurrent measurements during four expeditions in 2003, 2005, 2013 and 2015, atmospheric reanalysis products, and satellite ice concentration data. It was established that in the 'icy' years accumulation of heat in the upper ocean layer is insignificant for the subsequent ice formation because the absorbed heat is mostly spent on the ice melt until the end of the summer. In the 'ice-free' years the ultimate heat storage in the upper mixed layer depends on the duration of the open water and the distance of the point of interest to the nearest ice edge. In a broader context, we considered possible links between the average ice area/extent in the August-September-October (ASO), and in the December-January-February (DJF) for two representative Arctic regions: the Eurasian segment, defined within the bounds 90-120°E, 65-80°N, and the American segment, defined within the bounds 150°E - 150°E, 65-80° N. Significant 'seasonal memory', characterized by the consistent change of the ice cover parameters in sequential seasons, was revealed in the Eurasian segment between 2007 and 2017. No linkage on seasonal time scale was found in the American segment, despite even stronger reduction of the ASO ice extent/area in this region after 2007-onwards. Possible explanation of the distinguished contrast between two geographical regions is an increasing (since 2007) intensity of a dipole circulation mode over the Arctic Ocean revealed in the reanalysis data. Circulation field of this dipole structure delivers warm air to the Eurasian segment and cold air to the American segment, thus affecting the rate of the surface water cooling in the fall, and altering the time before the onset of freezing. This study was supported by RFBR, grant 17-05-41197.