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On contributing factors to the winter record low of the northern hemisphere sea ice extent in 2015

Neven-Stjepan Fuckar (1), Francois Massonnet (1,2), Virginie Guemas (1,3), Javier Garcia-Serrano (1), Omar Bellprat (1), Francisco Doblas-Reyes (1,4), and Mario Acosta (1)

(1) Barcelona Supercomputing Center (BSC), Earth Sciences Department, Barcelona, Spain (neven.fuckar@bsc.es, nevensf@gmail.com), (2) Georges Lemaitre Center for Earth and Climate Research, Earth and Life Institute, Universite catholique de Louvain, Louvain-la-Neuve, Belgium, (3) Centre National de Recherches Meteorologiques, Meteo-France, Toulouse, France, (4) Institucio Catalana de Recerca i Estudis Avancats, Barcelona, Spain

The northern hemisphere (NH) sea ice extent (SIE) has reached the record low in the satellite era (since November 1978) in March 2015. Would the 2014/15 fall–winter atmosphere yield this sea ice extreme if we reversed in time the long-term change in the ocean and sea ice state? We examine the contributions of the atmosphere and the long-term memory of the ocean and sea ice to the March 2015 record low of the NH SIE with a state-of-the-art ocean-sea-ice general circulation model (OGCM: NEMOv3.3). First, we perform a set of 5-month-long retrospective control simulations initialized on 1 November from 1979 to 2014 to assess the model skill in predicting the NH March SIE. We produce ERA-Interim-forced five ensemble members initialized from the five members of the ORAS4 ocean reanalysis and the associated five-member sea ice reconstruction. A climate variable can be decomposed into the sum of the background state represented as a linear fit over the period of interest and an interannual anomaly with respect to this fit: var(t) = [at + b] + var'(t). More specifically, initial conditions (IC) and surface forcing fields contain: (i) linear-fit background state of IC, (ii) interannual anomaly in IC with respect to factor (i), (iii) linear-fit background state of surface forcing fields, and (iv) interannual anomaly in surface forcing fields with respect to factor (iii). Next, we conduct two sets of sensitivity experiments with IC and surface forcing fields modified in such manner so that one set examine the influence of 2014/15 fall–winter atmospheric conditions, while the other focuses on the influence of change in linear-fit background state of the ocean and sea ice cover. Our forced experiments indicate that the most important factor driving the NH SIE to the record low in March 2015 was surface atmospheric conditions on average contributing at least 54% to the change from the past March states to 2015. The 1 November 2014 interannual anomaly of IC, which on average contributes less than 10%, is the least important factor. A change along the 36-year linear-fit of IC, representing the accumulative impact of the climate change in the ocean and sea ice, is the second most important factor for attaining the March 2015 extreme in our experiments. Even if we keep IC and forcing factors (ii) through (iv) in the 2014–15 conditions, but translate the background state of ocean and sea ice, IC factor (i), more than three years into the past, it prevents Arctic sea ice in our OGCM from reaching this record low. We conclude that March 2015 interannual surface anomalies in the Sea of Okhotsk and the Bering Sea are necessary transient, but not sufficient, conditions to achieve the record low of the NH SIE maximum in March 2015 without underlying climate change.