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The Cryosphere Discussions

Interactive comment on "Limitations of a coupled regional climate model in the reproduction of the observed Arctic sea-ice retreat" *by* W. Dorn et al.

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We thank the anonymous referee for his/her helpful comments on the discussion paper which have contributed to remove ambiguity, to avoid misinterpretation, and to improve the paper in the end. In the following, a detailed response to all comments is given referring to the numbering in the Referee Comments.

(Page and line numbers in square brackets refer to the revised manuscript.)

1.) The referee's major concern to the paper is the existence of some arguable and sometimes misleading conclusions, particularly in terms of the role of the initial state of the Arctic Ocean.

Indeed, the Arctic Ocean's initial state was not discussed, except for the initial ice

conditions. Since our ensemble approach differs from the usual method of slightly disturbed initial fields, we think it is worthwhile discussing at least the initial sea-ice conditions (in accordance with the main topic of the paper). In contrast to the ocean state, the initial sea-ice conditions can be briefly summarized in a table and do not require additional figures. Nevertheless, our statement that "the present ensemble simulations can be used to estimate the impact of the Arctic Ocean's initial state on the variability of the Arctic climate system" is misleading and, in a strict sense, even incorrect. In fact, the time series of the ensemble members' ice extent and ice volume suggest that the "specific" initial state of the Arctic Ocean, including the sea ice, is not the crucial point for their different behavior after some decades. In the first decade of the simulations, there is even a convergent evolution with smaller differences than in the initial state. The divergent evolution afterwards can best be seen as nonlinear interplay of internal atmospheric, oceanic, and sea-ice processes. This is in agreement with other studies. For instance, Döscher et al. (2010), who modified only the initial sea-ice state for creating an ensemble of coupled regional climate simulations for a Pan-Arctic domain, came to similar conclusions. We also agree that our former formulations in terms of the impact of the initial state on the variability and its importance for realistic simulations were arguable. The internal variability arises from the nonlinear response to any disturbance or uncertainty in the initial state and not from the distinctiveness of the initial state itself. We have removed the misleading statement and have reworded the initial state issue in the whole paper [page 4, lines 111–114; page 6, lines 191–192; page 6/7, lines 197–198; page 7, lines 200–201].

The referee's concern we imply that the sea-ice initial state is crucial for realistic climate simulations can admittedly not be denied. However, it was actually unintended to give this impression. We know from own experiments with HIRHAM-NAOSIM that, in a climatological sense, the initial sea-ice state is forgotten after about 6–10 years (Dorn et al., 2007). This finding is in agreement with the GCM studies by Schröder and Connolley (2007) and Tietsche et al. (2011), but was unfortunately not mentioned in the discussion paper. We have now emphasized this fact in the revised version [page 7,

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lines 212–219].

A reliable estimate of the impact of distinct sea-ice and ocean initial states on Arctic climate simulations would require coordinated sensitivity experiments as exemplarily suggested by the referee, but this would go beyond the scope of this paper. Furthermore, the specific initial state should not play a role in a climatological sense after a sufficient spin-up time as noted before. We have now tried to remove ambiguity concerning this matter by making a clear statement [page 7, lines 218–219].

2.) Even though the ice volume in runG is constantly larger than the ensemble mean over a long period, the climatological average of all runs is almost identical with respect to the ice thickness pattern. RunG only shows a few centimeters thicker ice than the ensemble mean. This is illustrated in Figure 1 attached to this Author Comments. We have now added a brief discussion of the differences between the most extreme ensemble members (runC and runG) and the ensemble mean [page 5, lines 138–141].

3.) A discussion of the impact of the atmospherically driven sea-ice drift on summer sea-ice extent has been added to Sect. 4 [page 10/11, lines 333–342].

4.) The study of Perovich and Richter-Menge (2009) has been included in the discussion of our results in Sect. 4 (Correlation between sea ice and atmospheric circulation patterns) and Sect. 5.2 (Summer 2007) of the revised version [page 10, lines 339–340; page 12, lines 402–404].

5.) The typing error on page 1286, line 6 in the discussion paper has been corrected [page 12, line 411].

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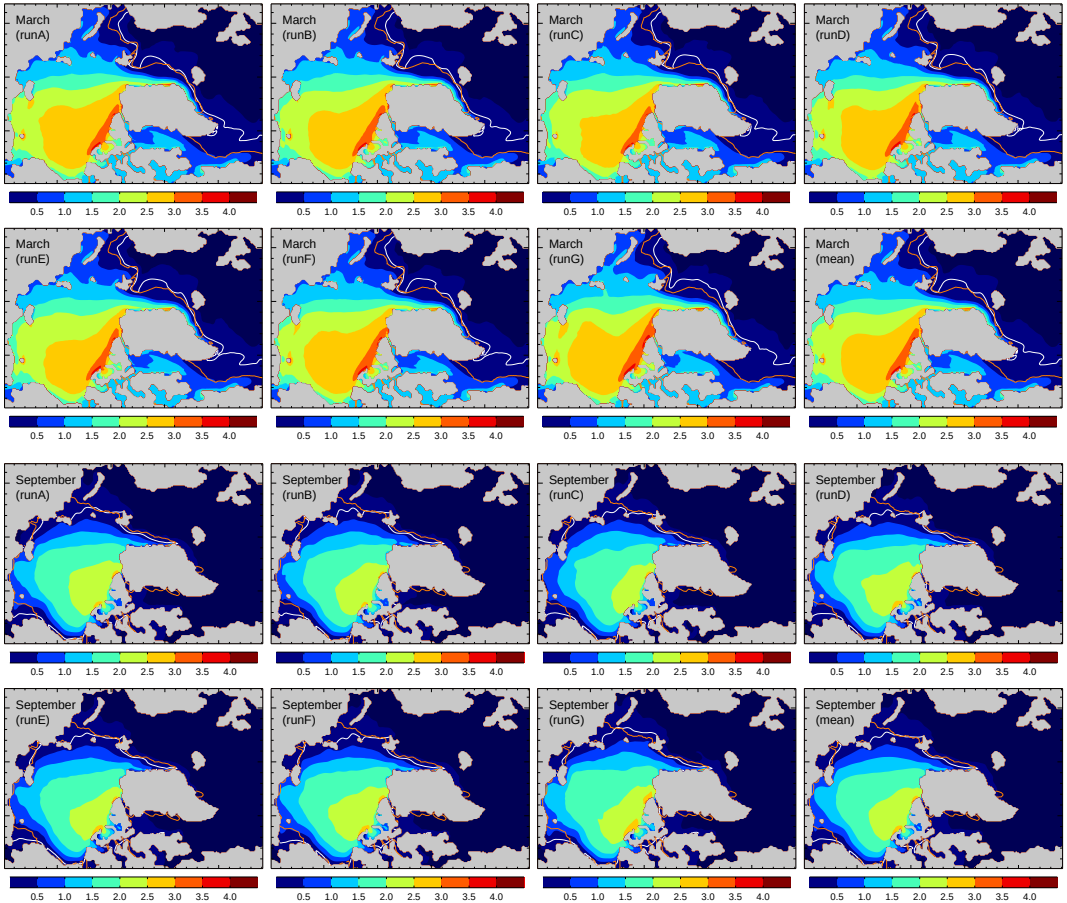

Fig. 1. As in Fig. 1 of the discussion paper, but for all 7 ensemble members (runA to runG) and the ensemble mean (mean).

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