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Interactive Comment

Interactive comment on "Summer Sea Ice Albedo in the Arctic in CMIP5 models" *by* T. Koenigk et al.

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We thank reviewer 2 for the constructive and helpful comments.

Specific comment

1. The sea ice albedo should have been an output parameter of CMIP5 models and been delivered to the archive. Unfortunately, we only found 3 CMIP5 models, which provided the "ice albedo". For one of these models, ice albedo was showing very strange numbers (obviously no albedo), which left us with 2 models. We therefore decided to use the method of Karlsson et al. (2013) to calculate the albedo via the solar radiation. For the two models, where we got the ice albedo from the CMIP5-archive, we compared the results to the ice albedo as calculated from the radiation and the results compared well. We are thus confident that our way to calculate the albedo

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results in reliable values.

2. We enhanced the discussion of uncertainties in ERA-interim data in the Observations and data section. We used ERA-interim surface temperature as done for all models as well.

3. We added some more description of the spatial distribution of sea ice concentration on page 25225.: Even models with realistic sea ice extent and sea ice trend (Massonnet et al. 2012) do not necessarily show an entirely realistic ice distribution (e.g. ACCESS1.3 and MPI-ESM-MR). They tend like a number of other models as well (CanCM4, Can ESM2, HadCM3, MPI-ESM-LR) to simulate highest ice concentrations in the middle of the Arctic Basin or in the Beaufort Sea and not along the north coasts of Greenland and the Canadian Archipelago as observed by satellites. And on page 25228: The spatial distribution of the observed sea ice albedo is not well reproduced in most models. Only nine (CanCM4, CanESM2, FGOALS-g2, GFDL-CM3, GFDL-ESM2M, MPI-ESM-LR, MPI-ESM-MR, MRI-CGCM3, NorESM1-M) out of the 21 models are able to simulate an ice albedo distributions, which is characterized by an albedo gradient between the area north of Greenland and the Canadian Archipelago and the coasts and ice edges as shows by CLARA-SAL. However, most of these nine models still underestimate the gradient or simulate too high albedo values in the entire Arctic. Three models (ACCESS1-3, EC-Earth, CNRM-CM5) show quite similar albedo values in most of the Arctic but at least a slight tendency to smaller values at the edges. Another seven models simulate almost the same ice albedo in the entire Arctic (CMCC-CESM, CSIRO-Mk3-6-0, GISS-E2-R, HadCM3, INMCM4, MIROC5, MIROC-ESM). HadGEM2-ES and particularly IPSL-CM5A-LR show highest ice albedos in the Atlantic sector of the Arctic and slightly lower in the Pacific sector.

Technical corrections:

1. 25221 L23: We changed it to: The surface albedo is strongly affecting the radiation budget of the Earth. Li et al. (2006) showed that already small changes in the surface

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albedo have a large impact on the climate.

2. 25222 L4: We cited Utall et al. (2002)

3. 25223 L22-25 The resolution of the CMIP5-grids varies between about 1° and 2.8°. We interpolated all model data on a 1° x 1° grid for better comparison. We added this to the text (Section 2.2). A detailed data set has the advantage that one might estimate the potential use of higher resolution in climate models for simulating the sea ice albedo. Particularly near the ice edge where small scale processes are very important, such a better resolution might be valuable.

4. 25224 L12-15 It is surface temperature. We added a short discussion and citation of Lüpkes et al. (2010) and Jakobson et al. (2012) to the Observation and data section.

5. 25225 L10-11 We deleted this sentence.

6. 25225 L23-24 We rewrote the sentence: Small differences among models in one or more of these variables might lead to large differences in the simulated Arctic climate since many feedbacks mechanisms (e.g. sea ice albedo, water vapour, lapse rate, cloud) are active in the Arctic and can amplify the signal.

7. 25228 L1-5 Yes, a number of models have a dependency on the ice thickness, at least for very thin ice. This might contribute to the ability of the models to simulate the reduced ice albedo towards ice edges or not. However, since a number of other processes like warmer surface temperature, more melt ponds, less snow could also lead to reduced ice albedos at the ice edge it would be rather speculative that the dependence on ice thickness is the most important reason why some models have a uniform ice albedo and others not. It is beyond the scope of this work to go into each model code and analyze each ice albedo scheme in detail.

8. 25229 L1 Yes, and also the same answer.

9. 25229 L3 We calculated the linear trend in every grid box. We did not treat boxes where the ice totally disappeared at some time between 1982-2005, differently. The

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sea ice concentration trend until 2005 was only moderate, particularly until the end of the 90s, so this does not affect many grid boxes and if the ice disappears, it disappears to the end of the time period and is thus not affecting the linear trend very much. But of course, in those boxes, we could get a smaller trend of sea ice albedo and this might not be very meaningful. Looking very careful at Figure 7, we do not see any clear signal near the ice edge, which would indicate a strong effect of this disappearing-problem. Only, in CLARA-SAL in August there are some smaller negative trends in a few points directly at the ice edge (smaller compared to the trend 2-3 grid points further into the ice) in the Greenland and Barents Sea, which might be caused by this problem. In the models, we find at the ice edge even some areas with slightly positive trends, which is probably due to natural variability. In single years, ice occurs in areas where normally no ice could be found. If this happens in the later part of the time period, we will see a positive trend. This underlines that we should be careful with interpreting signals directly at the ice edges and that is also why we focused specifically on the Central Arctic in section 3.4.

10. 25230 L29 and sq We split it into two sentences: However, ERA-interim surface temperatures are no observations and ERA-interim and CLARA-SAL do not originate from a consistent data set. Thus, the lower correlation between ERA-interim surface temperature and CLARA-SAL ice albedo compared to the models, does not necessarily indicate that models are overestimating the relation between surface temperature and ice albedo.

11. 25233 L3-4 The reviewer is of course right. It should be: However, models with extremely low and high ice albedo tend to simulate thin and thick ice, respectively.

12. 25234 L27-29 We replaced “sea ice albedo” by “melting ice albedo”.

13. 25235 Acknowledgements Thank you. We added an acknowledgement to the CMIP5 data providers.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 25219, 2013.