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The Cryosphere Discussions

Interactive comment on "Definition differences and internal variability affect the simulated Arctic sea ice melt season" *by* Abigail Ahlert and Alexandra Jahn

Anonymous Referee #2

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General comments

The paper investigates the difference in model definitions of melt onset and freeze-up using Community Earth System Model large Ensemble (CESM LE) and compared the results to the observation datasets from passive microwave (PMW) sensors. With 35 years of PMW observed melt/freeze dates were compared with different model outputs from CESM LE using different definitions based on different sensible physical processes. In addition, melt season lengths were calculated by combining varied definitions. The study concluded that none of the model outputs of melt/freeze-up dates matches with PMW results. The variation in melt dates is prominent compared to

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Discussion paper

freeze-up dates. The authors argued that these variations are mainly due to the varied surface/bottom processes involved during melt timing. In case of melt season length, the trend found in PMW observation in different from model simulations.

The paper is well written in a logical manner with necessary details. Figures are clear and well presented. The supplementary materials also complement the paper with additional information. The discussion was easy to follow. I have some major concerns with the content of the manuscript that need to be addressed.

The timing of melt from ice volume definition is unexpected. Fig 1a (and Fig 2d) shows MO date during YD (day of the year) 120-125, based on volume tendency definition. Most of the Arctic Ocean generally remains cold, therefore cannot initiate surface melt during that time of the year. For bottom melt, the ocean is still not warm enough during YD 120-130 to initiate bottom melt. Thermodynamically, none of the processes supports ice melt during this period. Considering the warm Atlantic/Pacific water intrusion in the Arctic, I think it should not result in basal melt all over the Arctic. Fig 3b shows large spatial differences in MO, where the Atlantic part of the Arctic experienced very early basal melt, which is expected. Perovich et al. (2008, GRL) observed bottom melt in the Beaufort Sea around YD 150. I would expect more variation of MO from ice volume tendency definition in Fig 1a, where the spread could be more towards YD 150-160. A descriptive statistics (number of grids vs MO date for ice volume tendency) would help to understand the variation in MO date in the region. A substantial effort is made to compare the model results with PMW observations to detect melt/freeze up while considering the detection of melt/freeze from PMW observation is absolute truth. Therefore, I strongly believe there should be a section describing PMW observation techniques to detect melt and freeze in a concise manner. This will help the reader to understand the process considered in the detection of melt/freeze up using PMW observations. The detection errors/limitation (from PMW observation) should be taken into consideration while comparing the results with model output. The melt/freeze timing difference between models and PMW observation could result due to multi-sensor calibration issues including detection methods of state variables, rather than definition diversity. Authors should consider this aspect in the discussion. This manuscript can be accepted after addressing these major concerns properly. I also provide some minor comments afterwards. I suggest Major revision.

Specific comments

Page 2 Line 1: The timing of ice retreat not necessarily defines melt onset (MO). After MO, other thermodynamic regimes (e.g. pond onset, drainage, break up) are observed in the Arctic before the ice starts to retreat. MO is a function on ice/snowmelt on sea ice, which can be detected by both passive and active microwave sensors, which is not the same as ice retreat.

Page 3 line 10: "... but large difference...." Is the mean difference statistically significant?

Page 4 line 25: "... a second using surface temperature..." is it NSTM or daily mean?

Page 4, line 29: most of the sea ice in the Arctic is found to be snow covered. As result, the ice melt would place much later in the season compared to snowmelt onset. Mostly, during pond onset, which is generated from snowmelt water, standing liquid water on ice surface starts melting the ice surface. Moreover, most of the ice melt takes place when the pond is drained and ice surface is exposed directly to the atmosphere. This ice-melt definition seems unrealistic in real-world scenarios in the Arctic.

Page 7 Fig 1a: Snowmelt and temperature definition has a good agreement until 2045. After that, snowmelt tends to occur well before temperature hits -1C. What physical process might cause this? Any reasonable explanation?

Page 9 Fig 3C: Why the Canadian Arctic Archipelago is not displayed in the MO map?

Page 10 Fig 4: Looks like all model definitions found Arctic warmer than it should be that ultimately delaying the freeze up compared to the PMW observations. This pattern is prominent, especially for the Central Arctic Ocean. It is interesting to see all definitions captured the spatial variability at the MIZ.

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