Reply to: Interactive comment on "Cyclone impact on sea ice in the central Arctic Ocean: a statistical study" by A. Kriegsmann and B. Brümmer, Anonymous Referee #1, Received and published: 31 May 2013

First, we thank anomymous referee No.#1 for the constructive and helpful comments. *Referee comments in Italics,* our answers in Roman.

I recommend that this manuscript be accepted for publication with minor revisions. The authors investigate in their paper "Cyclone impact on sea ice in the central Arctic Ocean: a statistical study" the impacts of cyclones on the Arctic Sea ice using a purely statistical approach. The title of this paper fits the work very well. They use the NAOSIM model, forced by ECMWF analysis for the period 2006–2008, and extract counts of cyclones using a well-recognized cyclone tracking algorithm. They present and discuss their results well, including a detailed region-by-region discussion of the identified statistical linkages. This work represents a relevant scientific topic that certainly falls within the scope of 'The Cryosphere.' The paper makes use of existing concepts, ideas, tools, data, etc. but present a valuable statistical discussion of Arctic cyclones during a time period where sea ice was observed to be in rapid decline. Substantial conclusions are reached within the paper following rigorous scientific methods and assumptions which strongly support the conclusions of the paper. The methods and datasets used within this paper appear to be well-described by literature, and I have no doubt that this work could be reproduced by others. The use of literature throughout this paper is appropriate and at an acceptable number of cited articles. I would suggest a few more process-oriented papers could be included, particularly on the implications of cyclones upon dynamic and thermodynamic processes in sea ice.

The following process-oriented papers were included:

- Haapala et al. (2005)
- Kawaguchi and Mitsudera (2008)

The abstract well-summarizes the results of the paper, but perhaps could use a few key statistical results.
We decided rather to stay at a general level, because the results are quite differentiated.

Page 1143: line 9: A reference would be good here, perhaps Perovich et al., 2008.
We added Perovich et al. (2008).

Page 1144: Line 13: Cite Simmonds and Rudeva, 2012.
We added Simmonds and Rudeva (2012).

Page 1145: Is NAOSIM just a name, or is it an acronym for something?
NAOSIM is the 'North Atlantic / Arctic Ocean Sea Ice Model', see page 1144, line 18.

Page 1147: Line 21: How do you gauge ice strength in this paper? Do you have a metric for this?
Ice strength P is calculated in the model as $P = P_* h \exp(-C(1-A))$, where P_* is the constant ice strength parameter ($P_* = 15,000\,\mathrm{Nm}^{-2}$), C is a constant, h is ice thickness, and A is ice concentration. P indicates how much internal stress can occur before the ice reacts with plastic deformation.

Page 1150: line 12, its "becomes" not "becames"
We changed it.

Page 1151: Using AMSR-E to gauge day-to-day changes in sea ice concentration is tricky due to error inherent to the algorithms used to process the passive microwave brightness temperatures. I would suggest addressing AMSR-E error in your paper.
On Page 1147, Line 9–14, we cite Spreen et al. (2008) and added to the text the ASI-algorithm for the calculation of the AMSR-E ice concentration. Spreen et al. (2008) also analyses the error of the algorithm. We introduce on page 1147 (of the discussion version) the ADiff-Filter in order to exclude detections where the ice concentration of AMSR-E is totally different from the simulated ice concentration.

Page 1152: Line 26: I think you may need to add a brief discussion about cyclone impacts on sea ice

concentration due to divergence / convergence from surface winds.
We added a sentence on page 1150, line 26 (discussion version) refering to the main processes which cause the change in ice concentration, namely divergence/convergence of ice drift and deformation of ice drift (because it fits already at that part of the paper).

Page 1153: Line 1-2. The changes you present here are pretty small and may fall within AMSR-E instrument and algorithm error. This goes with my above comment.
The values presented are from the model and are based on a large number of detections.
How large is the error of the AMSR-E if averaged over a large number of detection cases? If the used ASI-algorithm has a random error, a large number of detections should reduce the error of the mean. If the algorithm has a bias, our approach to look only at 24h-differences might furthermore help to reduce the error.

Line 27 "cylone"
Line 28 "growths" . . . should be 'grows' or 'increases.'
Page 1154: "Impact of a cyclone in winter is nearly completely vanished. . ." This seems like an awkward way of saying this. Try :"The impact of a cyclone in winter is greatly diminished after about 5 days..."
Line 27: "Canadian coast" this is too generalized. Best to say "Canadian Arctic Archipelago." This is what you mean?
We corrected all errors and changed the sentences as recommended.

Page 1155: Are the changes in SIC presented statistically significant?
Removed a sentence with not shown results.
We performed a t-test to calculate the significance of the change in ice concentrations between t=-1d and t=+1d. In DJF and MAM, results are highly significant ($p < 0.01$), the result for JJA is significant ($p < 0.05$). In SON the significance is slightly missed ($p = 0.052$). Relating to the regions, all results are significant (Sib) or highly significant (all others). Relating to the intensity, the result for intensity class 1 is significant, for the other classes the results are highly significant.

Page 1157: Line 12, I would suggest that cyclone impacts on SIC depend by season. In summer, ice can actually end up diverging quite a bit following a summer cyclone, due to the ice being broken up by wave forcing, and rapid in situ melt, ice floe size being key. Your point about ridging is valid for the entire cold season.
This point on different seasonal impacts on SIC is now clearer addressed in the conclusions.
New conclusion:
On the short time scale (less than 12 hours) of a passing cyclone, freezing and melting play a minor role in the change of ice concentration. Thus, the cyclone-induced reduction of ice concentration is almost solely due to ice drift divergence and ice sheet deformation. This means that there is no loss of ice mass. The following processes, freezing and melting, have different longer-term or even climatologic consequences in winter and summer. In winter, the heat flux between ocean and atmosphere over the cyclone-induced open water areas is increased for a few days. This heats and moistens the shallow Arctic boundary layer. At the same time the freezing of the open water areas leads to the formation of new sea ice, so that a further important impact of the wintertime cyclones is an increase of the Arctic ice mass. In summer, the cyclone-induced reduction of sea ice concentration is largest and the open water areas remain open. This summertime impact is expected to be especially large in areas with thinner ice as e.g. on the Siberian side and in areas with smaller ice floes as e.g. in the marginal ice areas of the Arctic Ocean.

References

J. Haapala, N. Lönnroth, and A. Stössel. A numerical study of open water formation in sea ice. *J. Geophys. Res.*, 110, 2005. C09011, doi:10.1029/2003JC002200.

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