

# ***Interactive comment on “Impacts of large-scale atmospheric circulation changes due to winter sea-ice retreat on Black Carbon transport and deposition to the Arctic” by L. Pozzoli et al.***

**Anonymous Referee #1**

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Pozzoli et al. investigate how changes in three circulation patterns defined in another study influence the transport of black carbon aerosols to the Arctic and the deposition there. The topic is interesting and within the scope of ACP. While the statistical methods the authors use to link the transport of BC with circulation patterns seems valid and well-explained, I am concerned about how the study is presented in general. The authors conclude that changes in atmospheric circulation patterns due to Arctic warming and reduced sea-ice has significantly impacted the BC transport and deposition. For instance, the authors argue that increased blocking over Scandinavia has led to an increase in deposition in West Arctic. The link between Arctic climate change and weather at mid latitudes is controversial, and the authors do not show any attempt to

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discuss this at all. There is hardly any comparison with previous work or with observations. Therefore, I cannot recommend publication of this manuscript in its current form. Below are some recommendations for improvements.

General comments:

1. I think you need to explain the method in Dobricic et al. 2016 in a bit more detail in terms of correlations factors and eigenvalues, as this study is important for your results. How much of the wintertime variability do the patterns explain? How are these patterns linked to sea-ice melting? For instance, you say that: 'The relationship between NAO and SB and the sea ice melting over the Arctic is visible in near-surface temperature trends, the associated warming over the Arctic is the largest over the Barents Sea and west of Greenland.' There is a relationship because you see similar geographical patterns?
2. I think a discussion of the uncertainties using a 'simple' cause-and-effect approach should be included here. The Arctic climate system is complex and noisy, and relationships between e.g. sea-ice retreat and circulation patterns are nonlinear. Many processes may mask each other out. A new perspective paper in Nature Climate Change highlights some of these challenges, and argue that a single cause is unlikely: <http://www.nature.com/nclimate/journal/v6/n11/pdf/nclimate3121.pdf>
3. In general, I think this manuscript should include more references to previous work.
4. Your conclusions differ from other studies. Hirdman et al. 2010 as you mention in the introduction, finds that changes in emissions were dominant, and that circulation changes only explained a minor fraction of the observed trend. How is your study different? And why do you think they differ so much? Please put your work into context.
5. There are no comparisons with observations at all. The observations in the Arctic are sparse, but at least there are some stations with in-situ measurements of BC.
6. The language needs a clean-up. Also the manuscript could improve by focusing on

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the main points, and leave out less important content.

Specific Comments:

Page 1, L10: 'Winter warming and sea ice retreat observed in the Arctic in the last decades determine changes of large scale atmospheric circulation pattern (..)' This is controversial. There is a lot of scientific debate whether the Arctic amplification influences the weather at mid-latitudes or not.

Page 2, L29-30: Can you provide references to some of these measurements that you refer to? Also change 'showed' to 'show'

Page3 L6: You need to specify that these are surface concentrations, as Hirdman et al. looked at measurements of EBC at 3 Arctic stations only.

Page 3, L22: 'We estimate the most likelihood BC distribution associated to three large scale atmospheric patterns which mainly contribute the winter near surface warming and sea ice retreat in the Arctic (Dobricic et al., 2016)'. I do not understand this sentence. As I read it you are saying that NAO is the main cause for the Arctic sea-ice retreat?

Section 2.2 needs more references on the atmospheric circulation patterns

Section 2.3: What is the time resolution of the data you are analyzing?

Section 2.3: You refer to many studies comparing your model to observations. Can you summarize the most important points regarding the Arctic and also scavenging?

Page 6, L4: reference to ECHAM5

Page 6, L14: which entire period?

Page 6, L23: Again the entire period. Can you instead specify the period? Is it 1980-2005?

Figure 1: Is this the trend for 1980-2000? Please specify.

Page 7 L12: Did you actually vary the natural variability and the emissions, or is this the reference run 1980-2000? I think this sentence is a bit confusing.

Page 7 L14: How is the wet dep and dry dep calculated?

Page 7 L18: Annually varying anthropogenic emissions are used for the REF simulation, and the BC anthropogenic emissions remained almost constant globally during the simulated period (1980-2005), 4.9 Tg/year, however large changes occurred in those source regions which are also mainly contributing to the transport of BC to the Arctic.' I guess what you mean here is that the global mean emissions of BC have not changed in magnitude during this period. Those source regions, can you specify? I also suggest to move parts of this to Methods, where you discuss the emissions.

Page 7, L25: The positive trend in BC burden is interesting and a bit surprising. You speculate that this is due to increased emissions in East Asia. But why do we then see the negative trend over Eurasia?

Page 7, L 29: 'The natural variability, or the changes in large scale circulation patterns which occurred in the last decades, determined a significant increasing trend of BC dry deposition and surface concentrations over the Arctic, BC wet deposition increased over the Canadian Archipelago and Greenland' Determined? Do you have evidence for this? Again, are you saying that the changes in the circulation patterns determined the change in the wet dep? There are many factors controlling wet dep. The way you are phasing this it sounds like natural variability is the change in circulation patterns?

Page 8, L9: 'Three large scale atmospheric patterns were identified by Dobricic et al. (2016) as the main drivers of the near surface warming in the polar region.' The main drivers for Arctic amplification?

Page 8, L10: Can you say a bit more about these trends? Which months?

Page 8, L121: Do you refer to a particular year for the negative phase of NAO here?

Page 9, L2: 'The BC load has a positive trend over most of the Arctic Ocean, Greenland

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and the Canadian Archipelago, and it is related to the presence of the anticyclonic circulation trend over the pole and the cyclonic trend over the North Atlantic extending over Europe.' How do you know this is related, have you showed this? Can you explain this a bit more?

Page 12 L4: 'Different studies found significant connections between the winter sea ice retreat in the Arctic observed in the last decades and changes in the large scale atmospheric circulation.' Which studies do you refer to? Please add this. Also, there are also many studies that have not found any significant connections.

Page 12 L6: What do you mean by 'well approximated', please be more specific. Conclusions: Are you saying here that there is an increase in the blocking frequency over Scandinavia? Again, I miss a discussion here. The number of blocking events and trends detected or not are sensitive to which detection algorithm that is used. E.g. Barnes et al., GRL, 2013 did not find any robust trend in blocking using three different detection methods. The findings you have are based on pure statistical methods (both the ICA and the MLE), and I think that should be reflected more in the summary and in general.

Technical Corrections:

Page 2, L3: 'has changed' to be consistent.

Page 2, L4: per decade

Page 2, L19: remove 'the' before BC

Page 3, L4: a situation

Page 3, L5: with cloud formation and precipitation with deposition to the surface, do you mean with resulting deposition, because of precipitation?

Page 3, L15: north to North

Page 4 L4 associated 'with' (many places)

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