We would like to thank the reviewer for the constructive comments. We have tried to address all of them as detailed below (our answers to each point are formatted in italic, with page and line numbers of the new revised manuscript in squared brackets).

Anonymous Referee #3

Pozzoli et al. investigated how the black carbon transport and deposition in the Arctic is affected by changing atmospheric circulations. The topic is important given the radiative forcing effects caused by black carbon and other absorptive aerosols could significantly affect Arctic climate. I think this paper should be of great interest to the readers. The simulation experiments and statistical analysis of how the changing atmospheric circulation could affect black carbon transport and deposition in the Arctic is well constructed. Uncertainty and robustness of the statistical analysis is also discussed. However, I think some caveats exist in the link between Arctic warming and changing atmospheric circulation and possible feedback mechanism proposed in this paper. More detailed discussions should be included in order to support this argument.

Overall, it is an important study, and should be considered for publication, after the issues mentioned in the reviews have been resolved. Some suggestions for improvements are listed below:

Comments:

Page 4, Line 13-15: Please provide more analysis and discussion of how well the Gaussian distribution assumptions hold. Or please cite other references which could support the assumption of Gaussian distribution here.

We have added the following explanation in Section 2.1 [Page 4, L17-L20]:

"In order to simplify the mathematical solution of the problem we assume that the two distributions, ***p(a|c)*** *and* ***p(c),*** *are approximately Gaussian, meaning that also their product,* ***p(c|a)****, will be Gaussian. This assumption is supported by the Central Limit Theorem, which tells that the distribution produced by several processes with non-Guassian distributions should appear closer to a Gaussian distribution (e.g. Hyvärinen and Oja 2000). "*

Page 7, Line 16 - 19: "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 (Figure S1)." I think this part should include more details, such as a list of names of those regions have large changes in this period?

We agree with the reviewer and we moved the description of the emission scenario in Section 2.3. The new version reads as follow [Page 7, L7-L12]:

"The BC anthropogenic emissions remained almost constant globally during the simulated period (1980-2005), 4.9 Tg/year, however large changes occurred in North America, Europe and East Asia (Figure S1a,c). Most of the anthropogenic BC is emitted between 30°N and 60°N, and decreased after the 1990s from about 3 Tg/year to about 2.6 Tg/year after 2000. Above 60°N BC anthropogenic emissions are a small fraction of the total and decreased from 100 to 30 Gg/year. The simulation includes also inter-annual varying biomass burning emissions, from tropical savannah burning, deforestation fires, and mid- and high latitude forest fires published by Schultz et al. (2008). BC biomass burning emissions are

ranging between 10 and 170 Gg/year above 60°N, and between 35 and 460 Gg/year at mid-latitudes, with peak years connected also to inter-annual meteorological variability (Figure S1b,d).”

Page 8, Line 24 - 26: Please specify how the arrows are determined from the trends. Is that a qualitative representation of the tendency of main atmospheric circulation path? Is that path corresponding to black carbon transport path?

[Page 24] With the arrows in Figure 3 (Figure 1 in the new version of the manuscript) we intended to give a qualitative representation of the tendency of the circulation paths associated to each independent component pattern. Thus, they also represent the tendency of the pollutant transport pathways.

Page 9, Line 4 - 7: "This pattern, as the negative phase of the NAO, is characterized by weaker westerlies, colder and drier conditions in Scandinavia and Russia, warmer temperatures over Greenland and Canadian Archipelago with higher precipitations and BC deposition. Dynamically it also imposes stable conditions in which the pollution may accumulate in the polar dome over the Arctic." I think more analyses or references should be provided here to support the argument about changes of atmospheric conditions associated with negative phase of NAO. Also, please clarify the relationship between higher precipitation and BC deposition over Greenland and Canadian Archipelago and the stable condition mentioned later. It’s not clear that whether it is most parts of the Arctic becomes more stable except Greenland and Canadian Archipelago? I think additional analysis is necessary for this part.

We thank the reviewer for highlighting this inconsistent analysis. We have cleaned the entire paragraph from repetitions and inconsistencies, and now it reads as follow [Page 10, L7-L21]:

*“The tendency of IC_{NAO} toward the negative phase of the NAO (**Error! Reference source not found.**a) forms an anticyclonic anomaly over the large part of the Arctic Ocean and a cyclonic anomaly in the North Atlantic Ocean. The intensity of westerly winds is decreased in the lower troposphere, with lower transport of pollution from North America across the Atlantic Ocean. On the other hand, the IC_{NAO} slightly increases the transport of pollution from northwest America towards the Arctic Ocean. Consistently with the circulation pathways described in **Error! Reference source not found.**a, the MLEs of BC wet deposition trends related to IC_{NAO} (**Error! Reference source not found.**) show a decreasing trend north of the Eurasian coast and an increasing trend north of America and Greenland. A correlation between the negative phase of the NAO and increasing precipitations and snow accumulation over Western Greenland was also found by previous studies (e.g. Appenzeller et al., 1998; Mosley-Thompson et al., 2005). The BC load has a positive trend over most of the Arctic Ocean, Greenland and the Candian Archipelago, which may be associated with the dipole of pressure anomalies over the Pacific Ocean which is also favouring the export of polluted air masses from East Asia into North America and the Arctic (**Error! Reference source not found.**a). Sharma et al. (2013) previously showed that the contribution of East Asian BC emissions in the Arctic above 200 mb is the largest.”*

Page 12, Line 4-5: "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." Please add reference papers to this section.
We have expanded the discussion on this point (see also answers to reviewer #1). The first paragraph of the conclusions Section, now reads as follow [Page 13, L17-L23]:

“The feedbacks between the global warming and arctic amplification with sea-ice retreat and impacts on large-scale atmospheric circulation are still contradictory. The response of mid-latitude weather to the Arctic warming and sea-ice cover changes of the last decades is highly uncertain due to nonlinear processes involved in the Arctic and subarctic climate system (Overland et al., 2016). Some studies find only weak or non-existent relationships between mid-latitude weather structures and Arctic warming (e.g. Screen and Simmonds, 2013; Barnes et al., 2014), while others found correlations between sea-ice retreat in winter over the Barents and Kara Seas and hemispheric scale impacts (e.g. Deser et al., 2007; Petoukhov and Semenov, 2010; Screen et al., 2013; Mori et al., 2014; Di Capua and Coumou, 2016).”