We thank the reviewer for the helpful comments, which certainly improved the manuscript. Especially, due to more detailed descriptions of the background and discussions of the main topic the manuscript has improved significantly. The detailed replies on the reviewer's comments are structured as follows. Reviewer comments have bold letters, are labeled, and listed always in the beginning of each answer followed by the author's comments including (if necessary) revised parts of the paper. The revised parts of the paper are written in quotation marks and italic letters.

Major Issues:

1. **The introduction is too long. Even after reading the second page, I am not sure why we should worry about the inhomogeneity in the cloud radiation properties aka optical depth. Is it because we need better sub-grid characterization of radiative properties in global climate models? It will be better if the authors explicitly state the specific objective of the study.**

The reviewer is right. The introduction was written too general and broad on Arctic clouds. We have shortened it and put the focus stronger on the cloud inhomogeneities and their directional structures. Please find below the revised introduction:

"Arctic clouds are expected to be a major contributor to the so-called Arctic Amplification (Serreze and Barry, 2011; Wendisch et al., 2017) and, therefore, need to be represented adequately in model projections of the future Arctic climate (Vavrus, 2004). Especially, low-level Arctic stratus are of importance (Wendisch et al., 2013), because they occur quite frequently (around 40 %, Shupe et al., 2006, 2011), typically persist over several days or even weeks (Shupe et al., 2011), and on annual average, warm the Arctic surface (Shupe and Intrieri, 2004). The numerous physical and microphysical processes that determine the properties of Arctic stratus are complexly linked to each other (e.g., Curry et al., 1996) and still not understood in full detail (Morrison et al., 2012).
Dynamic factors (updrafts), which increase the actual supersaturation in the cloud beyond the equilibrium values for both liquid water and ice, and a steady supply of water vapor from above the cloud act to stabilize the Arctic stratus (Shupe et al., 2008). This facilitates the simultaneous existence of both phases (Korolev, 2007). While in updrafts liquid and ice crystals grow, the cloud top cooling induces downward vertical motion, where Wegener-Bergeron-Findeisen process may dominate. Therefore, small–scale structures can be important to understand the microphysical processes. Additionally, Arctic stratus shows microphysical inhomogeneities, which typically occur on horizontal and vertical scales below a few kilometers and even tens of meters (Chylek and Borel, 2004; Lawson et al., 2010). The small–scale cloud structures, which accompany cloud inhomogeneities, lead to three-dimensional (3D) radiative effects (Varnai and Marshak, 2001), which can be parameterized using inhomogeneity parameters (Iwabuchi and Hayasaka, 2002; Oreopoulos and Cahalan, 2005).
Unfortunately, the understanding of Arctic clouds is impeded by a paucity of comprehensive observations due to a lack of basic research infrastructure and the harsh Arctic environment (Intrieri et al., 2002; Shupe et al., 2011). Therefore, observation of small–scale cloud structures within the Arctic circle are sparse. Satellite observations are typically too coarse to resolve scales below 250 m and space–born passive remote sensing observations suffer from contrast problems over highly reflecting surfaces (snow and ice, Rossow and Schiffer, 1991). Ground–based remote sensing observations with radar and lidar typically point only in zenith direction and are not capable to provide the horizontal 2D–structure of clouds. Only along the wind direction the variability of clouds is resolved (Shiobara et al., 2003; Marchand et al., 2007). For example, using correlation analysis, Hinkelmann (2013) revealed significant differences between along–wind and cross–wind solar irradiance variability on small spatial scales in broken–cloud situations. In comparison, airborne spectral imaging observation of reflected solar radiation provide areal measurements with spatial resolution down to several meters (Schäfer et al., 2015). Bierwirth et al. (2013) used such airborne measurements of reflected solar spectral radiance to retrieve fields of cloud optical thickness τ of Arctic stratus and demonstrated their strong spatial

variability. From similar measurements, Schäfer et al. (2017a) analyzed the directional variability of different cloud types including Arctic stratus. The few analyzed cases revealed that 1D statistics are not sufficient to quantify the variability of horizontal clouds inhomogeneities.
Likewise, treating small–scale inhomogeneities using reanalysis data and atmospheric models is difficult. Global reanalysis products have relatively coarse spatial resolutions (40 km and larger; Lindsay et al., 2014) and, therefore, do not resolve small–scale features. Furthermore, in numerical weather prediction and climate models, the representation of the temporal evolution of mixed-phase clouds is poor (Barrett et al., 2017a, b). Especially, areas of up- and downdrafts in Arctic stratus, which are typically in the range of less than 1 km cannot be resolved but have to be parametrized (Field et al., 2004; Klein et al., 2009). To realistically simulate the spatial structure of these clouds, Large Eddy Simulations (LES) with a spatial resolution of 100 m or less and high vertical resolution (< 20 m within atmospheric boundary layer, ABL) are needed. Those LES can resolve the vertical motion of the turbulent eddies in the ABL and the cores of up- and downdrafts representing the inhomogeneities in the cloud top structure, which can be seen in the amount of liquid water at the cloud top. The size of the up- and downdraft cores may differ depending on the time of the year (Roesler et al., 2016).
Previous LES studies focus for instance on cloud-top entrainment (Mellado, 2017) and emphasize the behavior of changes in the spatial resolution on the liquid water path (Pedersen et al., 2016). Kopec et al. (2016) discussed two main processes, the radiative cooling and wind shear. The radiative cooling sharpened the inversion, while wind shear at the top of the ABL causes the turbulence in the capping inversion and lead to dilution at the cloud top.
In general, LES are helpful to focus on a certain process and to investigate cloud formation, cloud evolution or the small–scale structures in an Arctic stratus under controlled conditions. The further aim is to characterize horizontal small–scale cloud inhomogeneities in the size range of less than 1 km in simulations and measurements to better understand the radiative properties of Arctic mixed-phase clouds. Results from the COSMO (COnsortium for Small-Scale MOdeling) model, which is adjusted to a LES setup with a high horizontal and vertical resolution to resolve the cloud structures of Arctic stratus (Loewe et al., 2017; Stevens et al., 2017) are evaluated. For the Arctic Summer Cloud Ocean Study (ASCOS), Loewe et al. (2017) validated COSMO for simulations with a spatial resolution of 100 m with respect to droplet/ice crystal number concentrations, cloud top/bottom boundaries, and surface fluxes. Cloud structures and inhomogeneities were not validated due to the lack of observational data. Here, airborne imaging spectrometer measurements obtained during the VERDI campaign are used to analyze the small–scale cloud inhomogeneities (< 1 km), which are then compared to COSMO simulations using the same model setup as proposed by Loewe et al. (2017) with 64 by 64 grid points and 100 m spatial resolution as well as a finer resolved setup with 32 by 32 grid points and 50 m spatial resolution. For that, data measured by dropsondes served as input for semi–idealized simulations of clouds using COSMO-LES (Sec. 2.3 and Sec. 3). Airborne measured fields of cloud optical thickness retrieved from imaging spectrometer measurements (Sec. 2.2) are used for a comparison with the resulting COSMO clouds with respect to their overall cloud inhomogeneity and directional features of the cloud inhomogeneities (Sec. 4 and Sec. 5). Observations and modelling are aimed to be combined to quantify the horizontal cloud top structures, which are discussed in Sec. 5 and Sec. 6."

2. **It is unclear why you chose wind speed as a tuning parameter. By increasing wind speeds you are simple changing the fluxes in the boundary layer and hence the turbulence. So essentially your results are suggesting that we greater turbulence produces higher inhomogeneity, which makes sense. It will be better if the authors can probe this. One way to tackle this would be to make some simulations where the winds are the same, but you increase the surface fluxes.**

Thank you for your comment. Probably we did not describe our aim with changing the wind speed very well.

Our intention for changing the wind speed was to change the wind shear at the inversion and, therefore, turbulent processes at cloud top. As explained by the reviewer, this implicitly also changes surface fluxes. However, simulations by Loewe (2017) over different surface types (sea ice, open lead, open water), e.g. different surface fluxes, showed only an effect in the LWP, which was increased, but did not change the cloud structure. In these simulations, when the BL was coupled to the surface. The cases of the sensitivity study presented here, except of the 16 May cloud are characterized by a boundary de-coupled to the surface. Therefore, surface fluxes are expected to have a minor impact on the cloud layer. Thus, we chose to influence the cloud top structure by changing the wind shear. In the revised manuscript we added this dicussion in Section 6:

"Influences from the surface fluxes are only expected if the cloud is coupled to the surface and if so, affect only the LWP of the cloud (Loewe, 2017). For de-coupled clouds, it is assumed that the cloud structure depends more strongly on the wind shear, respectively the wind speed."

3. Lastly, the authors should show the comparison between the model reported liquid water paths, and cloud boundaries with those observed during the campaign. I think this will make the article complete. Thanks.

Unfortunately, such a comparison is not reasonably for this study, as the model was initialized with the atmospheric profiles (temperature, humidity, wind) observed during the campaign. Therefore, the cloud boundaries in the simulations are almost identical as those measured by the dropsonde profiles. Similar, the liquid water paths were adapted to the dropsonde profiles.

Minor Issues:

1. Line 58: Need reference to justify that sentence.

It was shown by Schäfer et al. (2017a). However, the tense was incorrect due to a typo. We corrected the sentence for this.

"From similar measurements, Schäfer et al. (2017a) analyzed the directional variability of different cloud types including Arctic stratus. The few analyzed cases revealed that 1D-statistics are not sufficient to quantify the variability of horizontal clouds inhomogeneities."

2. Line 101-102: I would simply say that the cloud fraction decreased. The word "dissolved" seems inappropriate in terms of clouds.

We changed "dissolved" to "decreased".

3. Line 121: By "ten fields" I believe you mean ten snapshots?

The reviewer is right. In general, these are only snapshots, which means only smaller parts of a larger cloud scene. However, referring to Schäfer et al. (2017a), we would like to keep on calling it "fields" of cloud optical thickness, although they do not capture the whole cloud scene.

4. **Section 3.1: Please describe the radiation and cloud schemes used in the model. Since you are evaluating optical depth, which is a radiative property, it is important to know this. Also mention how often the two schemes are talking to each other. Thanks.**

Thank you for your helpful comment. The other reviewer had a similar comment and we like to apply the same answer her.

The two-moment cloud microphysics scheme by Seifert and Beheng (2006) is used in the COSMO model. Within the model the number densities and the masses of six hydrometeor types are predicted. The six hydrometeor types are cloud droplets, cloud ice, raindrops, snow, graupel, and hail. The scheme is based on the partial power moments of the number density size distribution function of cloud droplets and raindrops. The different ice phase hydrometeor growth processes are parameterized, in which the depositional growth of ice particles is dominant in Arctic mixed-phase clouds.

The radiation is a two-stream radiation scheme after Ritter and Geleyn (1992). It is calculated every 2 s and has a direct cloud-radiative feedback.

The vertical resolution at the inversion height on the different days is comparable with a maximum vertical grid spacing of around 15 m up to the inversion height.

We added additional information about the cloud scheme, the radiation scheme and the vertical resolution in section 3.1. Further, the surface fluxes depend on the surface temperature, which is 273.5 K for the sea-water surface. We added this information in Sec. 3.1 as well.

"The two-moment cloud microphysics scheme by Seifert and Beheng (2006) predicts the number densities and the masses of six hydrometeor types. The different ice phase hydrometeor growth processes are parameterized in this scheme. In COSMO, the radiative transfer is described by a two-stream radiation scheme after Ritter and Geleyn (1992). It is calculated every 2 s and has a direct cloud-radiative feedback. A three-dimensional prognostic turbulence scheme describes the turbulent fluxes of heat, momentum and mass by a first-order closure after Smagorinsky and Lilly (Herzog et al., 2002; Langhans et al., 2012)."

"The vertical height range of 22 km is divided into 166 vertical levels, which are more dense for the ABL with a typical grid spacing of around 15 m up to the inversion height of the different days of investigation."

"The surface of the model is sea water and the surface fluxes depend on the surface temperature, which is 273.5 K for the sea water surface."

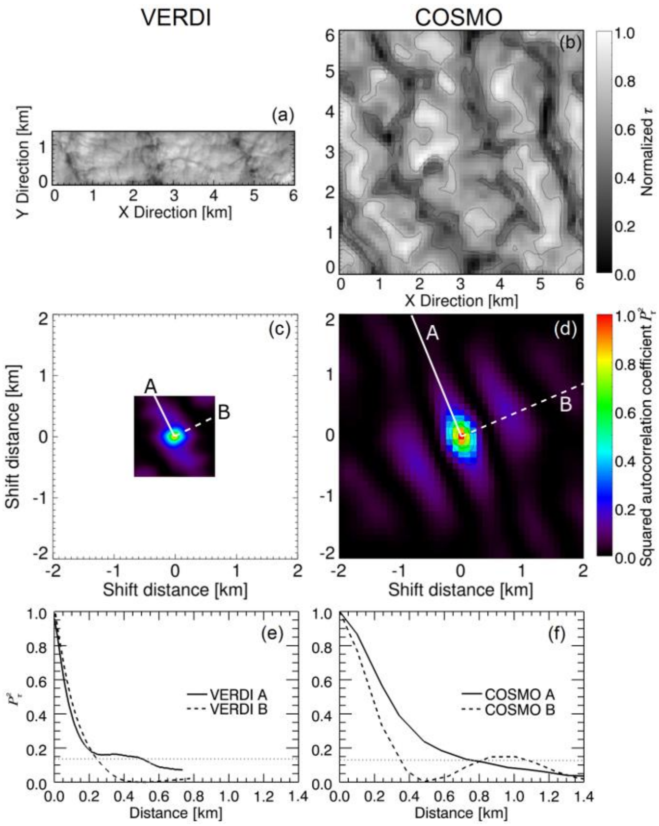
5. **Line 273-279: Please rephrase these sentences. It is confusing to read "large resolution" etc. thanks.**

We revised the relevant sentence by the following:

"Thus, the spatial resolution of AisaEAGLE is relatively high, compared to the grid spacing of 100 m from COSMO."

6. Figure 5e and 5f: There is no "grey dotted line" in the plot.

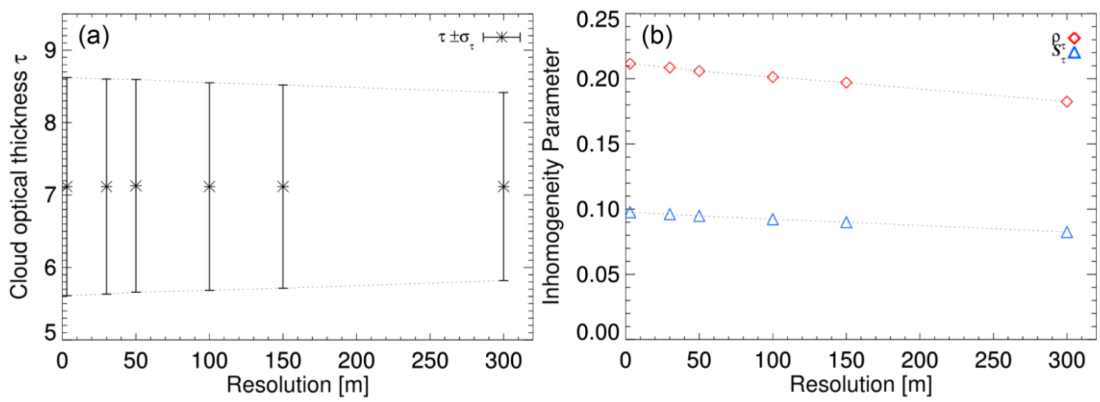
We have updated the graph shortly before we initially submitted the manuscript and must have missed to include this line in the new version. Now, it is included in the resubmitted version. Please see the graph below:



Revised Fig. 5 (now Fig. 4)

7. Figure 7a: the plot is showing mean and standard deviation, however there are two blue dots for each resolution? If you are showing mean+std and mean-std, then I suggest you show vertical error-bars.

We have changed the graph accordingly. Now we are using error bars. Please find the revised Figure below:



Revised Fig. 7 (now Fig. 6)