We thank the reviewer for the helpful comments, which certainly improved the manuscript. Especially, by evaluating the different spatial resolutions of the observations and the simulations and associated effects we are sure that the manuscript became more meaningful. 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) major revised parts of the manuscript. The revised parts of the manuscript are written in quotation marks and italic letters. Minor revisions of the text can be found in the additionally submitted mark-up file.

1. **The real problem of the study is insufficient resolution of the numerical simulations to effectively match the experimental data. The majority of efforts is set to averaging of the experimental data, which allows produce optical thickness fields of the resolution comparable to the model output due to limited model domain and poor resolution of the simulations. This causes that conclusions are weak and too far going.**

The reviewer is right that the differences between the original resolution of the AisaEAGLE observations and the COSMO simulations are a big issue. The primary reason for using the selected observations and the applied model resolution was based on a previous study by Loewe et al. (2017), where the COSMO model was compared to observations. For the 100 m grid spacing the comparisons of liquid/ice water content, size distributions of droplets and ice crystals showed good agreements. Therefore, we were confident with this model setup and first did not change the resolution for this study.
However, the reviewer is right that the large differences in the resolutions may not be comparable. Therefore, we added simulations, where we improved the grid spacing to 50 m. We tried to simulate with 25 m grid spacing, but this was not possible due to numerical instabilities. A reduction of the spatial domain could not solve this issue. A modification of the model, e.g. implementation of a different turbulence scheme, is beyond the scope of this work.
Throughout the discussion part of the manuscript, we now discuss the findings for both, 50 m and 100 m grid spacing. The comparison of both simulation runs did show significant differences, which show that the reproduction of small-scale cloud inhomogeneities depends on the model setup. In the revised manuscript this is explicitly analyzed and discussed. Including the new simulations with the new grid spacing of 50 m caused several changes in the manuscript. Please find below the main changes with regard to text parts, graphs, and tables:

Abstract:

"Simulations are performed for spatial resolutions of 50 m (1.6 km x 1.6 km domain) and 100 m (6.4 km x 6.4 km domain)."

"[…] show that COSMO produces more homogeneous clouds by a factor of two (100 m spatial resolution) compared to the measurements. Those differences reduce for the spatial resolution of 50 m."

Introduction:

"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"

Section 3.1:

"[…] The size of the model domain used by Loewe et al. (2017) was 6.4_6.4 km in horizontal direction with a spatial resolution of 100 m. Here, this setup is applied as well. However, analyzing cloud inhomogeneities requires a fine horizontal spatial resolution of the model simulations. Therefore, for the comparison with the imaging spectrometer measurements analyzed here, the spatial resolution is also increased to 50 m for addition model runs. In those cases, the domain size is reduced to 32 by 32 grid points (1.6 km x 1.6 km) for computational constrains. A further reduction of the spatial resolution was not possible due to numerical instabilities. […]"

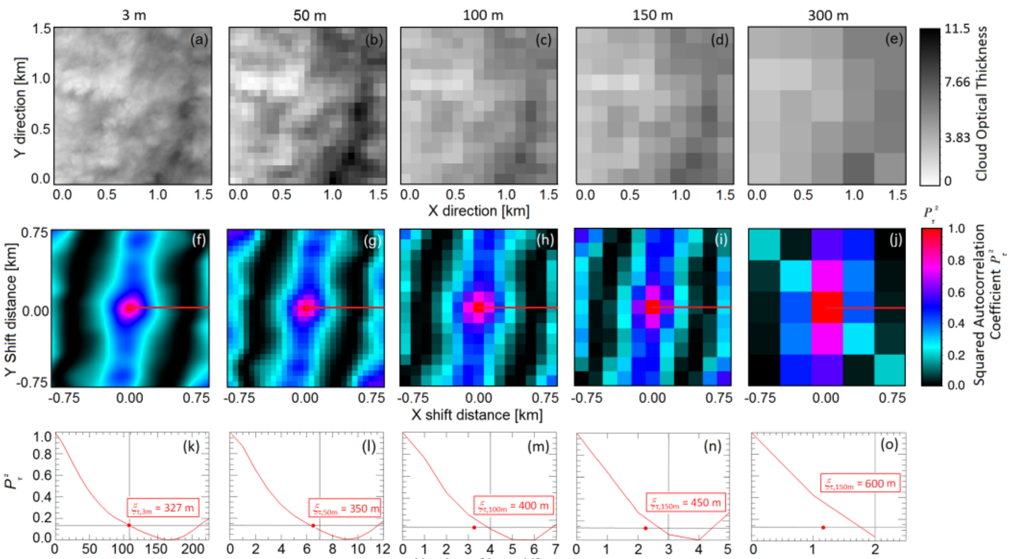
Section 4.3:

"The investigations on the single cases during VERDI are performed for spatial resolutions of 50 m (32 by 32 grid points) and 100m (64 by 64 grid points). All other model parameters are kept constant with respect to the analysis performed by Loewe et al. (2017). "

"In order to average the observed fields of τ_{meas} to the grid spacings of 50 and 100 m, the τ_{meas} -values of distinct numbers of neighboring pixels are averaged. The number depends on the single pixel size of the particular cases, which is a function of the distance between aircraft and cloud. For the four investigated cases this number varies between 13 (26) and 18 (36) pixels, which are needed to generate pixel sizes of τ_{meas} comparable to the 50 m (100 m) spatial resolution of COSMO. "

"For the COSMO simulations, which use 50m spatial resolution, the domain size is reduced to 32 by 32 grid points resulting in a total domain of 1.6 km by 1.6 km, which is comparable to the observations. Therefore, the domain of those simulations was not adapted for the comparisons."

"Therefore, in the following analysis, comparing the simulated against observed fields of τ, the simulations with the finer spatial resolution of 50 m are used. The simulations with 100 m spatial resolution are used to discuss the model sensitivity with respect the spatial resolutions."



*"**Figure 5 (was Fig. 6).** Illustrated are sections of one and the same field of τ_{meas} from 14 May 2012 with a spatial resolutions of **(a)** $\approx$3 m (original resolution), **(b)** 50 m (COSMO resolution), **(c)** 100 m (COSMO resolution), **(d)** 150 m, and **(e)** 300 m. […]"*

Section 5.1:

Table 2. Mean value of τ, standard deviation σ_τ, and the three 1D inhomogeneity parameters ρ_τ, S_τ, and χ_τ calculated for all four cases from the observations and the simulations with the two different grid spacings of 50 and 100 m.

	Case	$\bar{\tau} \pm \sigma_\tau$	ρ_τ	S_τ	χ_τ
VERDI (50 m)	14 May	7.8 ± 1.5	0.195	0.086	0.979
	15 May	6.4 ± 0.7	0.121	0.055	0.992
	16 May	6.4 ± 1.0	0.166	0.078	0.983
	17 May	4.2 ± 0.5	0.154	0.071	0.986
VERDI (100 m)	14 May	8.1 ± 1.2	0.209	0.093	0.977
	15 May	6.4 ± 0.5	0.115	0.052	0.993
	16 May	6.6 ± 0.6	0.145	0.065	0.988
	17 May	4.3 ± 0.4	0.132	0.061	0.990
COSMO (50 m)	14 May	7.9 ± 0.6	0.071	0.030	0.997
	15 May	7.1 ± 0.7	0.092	0.040	0.995
	16 May	6.0 ± 0.6	0.094	0.040	0.995
	17 May	5.8 ± 0.5	0.083	0.036	0.996
COSMO (100 m)	14 May	6.9 ± 0.5	0.066	0.028	0.997
	15 May	5.4 ± 0.3	0.053	0.023	0.998
	16 May	5.5 ± 0.5	0.090	0.037	0.996
	17 May	5.6 ± 0.3	0.044	0.019	0.999

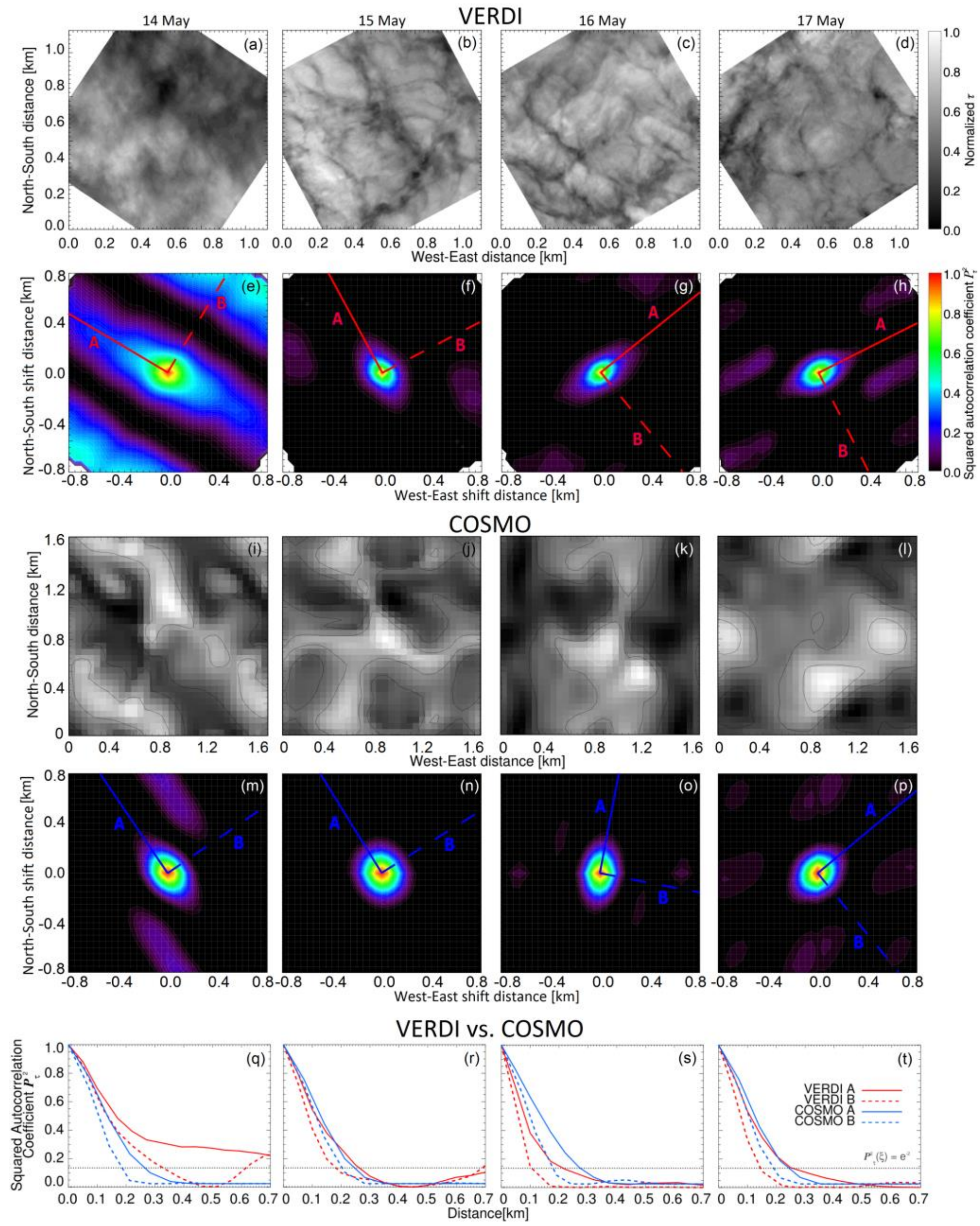
"[…] Table 2 lists the mean value of τ, standard deviation σ_τ, and the three 1D inhomogeneity parameters ρ_τ, S_τ, and χ_τ for the observations and the simulations with the two different spatial resolutions of 50 and 100 m.
Both, measurements and simulation show the highest cloud optical thickness on 14 May with τ_{meas} = 8.1 +/- 1.2 and τ_{sim} = 7.9 +/- 0.6 at 50 m spatial resolution and τ_{sim} = 6.9 +/- 0.5 at 100 m spatial resolution, which show an overall agreement. […] However, compared to the grid spacing of 100 m it is obvious that the finer resolved simulations lead to better agreements between measurements and simulations."

Section 5.2

"The 2D autocorrelation functions are calculated to compare the typical spatial scales and the directional character of the small-scale cloud inhomogeneities (no large-scale inhomogeneities like roll convection) of observations and simulations."

"Furthermore, the results for $P^2_{\tau,meas}$ and $P^2_{\tau,sim}$ show that COSMO simulations using a spatial resolution of 50 m produce similar sizes of the small-scale cloud structures compared to the measurements."

For the simulations with 100 m spatial resolution (graph not shown) the directional features still compare well between observations and simulations."



New Figure 7 (was Fig. 8) *shows now the results for 50 m grid spacing and not 100 m grid spacing anymore.*

Table 3. Calculated decorrelation lengths $\xi_{\tau,\mathrm{meas}}$ and $\xi_{\tau,\mathrm{sim}}$ for the two different resolutions/grid spacings of 50 and 100 m along ($\xi_\tau^{\updownarrow}$) and across ($\xi_\tau^{\leftrightarrow}$) the observed and simulated predominant directions (compare Fig. 7e–h and Fig. 7m–p for 50 m grid spacing).

	Case	$\xi^{\updownarrow}_{\tau,50\,\mathrm{m}}$ [m]	$\xi^{\leftrightarrow}_{\tau,50\,\mathrm{m}}$ [m]	$\xi^{\updownarrow}_{\tau,100\,\mathrm{m}}$ [m]	$\xi^{\leftrightarrow}_{\tau,100\,\mathrm{m}}$ [m]
VERDI	14 May	800	330	> 1000	400
	15 May	260	180	280	190
	16 May	220	100	350	170
	17 May	250	150	370	260
COSMO	14 May	260	190	530	320
	15 May	250	200	380	260
	16 May	270	180	500	280
	17 May	240	190	430	390

2. p. 5 Fig.2 Why you do not show wind components? Later you discuss directional shear...

It is true that it would be helpful to include the wind components. In the initially submitted version wind was partly included in Fig. 4, at least for COSMO. However, in the resubmitted manuscript we removed Fig. 4. Therefore, we now extended Fig. 2 by two panels (Dropsonde, COSMO) for the wind direction. As the dropsonde does not provide vertical wind, we limited the plot to horizontal winds, e.g. wind direction. Please find below the new Fig. 2 from the resubmitted manuscript.

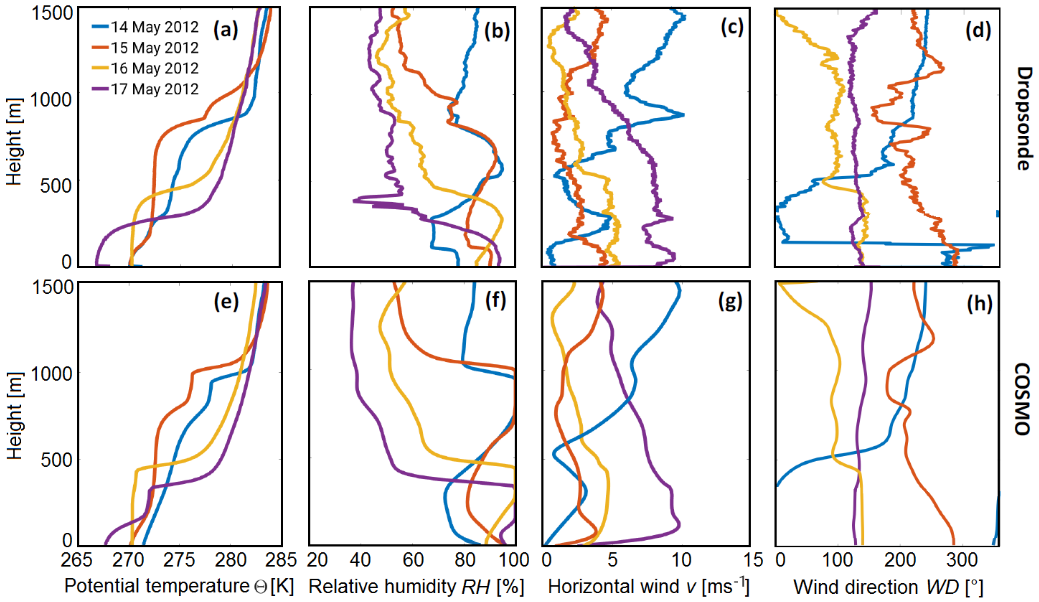


Figure 2. ***(a, e)*** *Potential temperature,* ***(b, f)*** *relative humidity,* ***(c, g)*** *wind speed, and* ***(d, h)*** *wind direction for the four investigated cases. The dropsonde data is shown in the first row (a-d) and the 2 h domain-averaged profiles after spin-up time of the simulations are shown in the second row (e-h). Dropsondes were released closest to the imaging spectrometer measurements.*

3. 3.1. Simulations Model set-up is not detailed enough. Please describe fluxes, radiation, microphysics in few sentences, referencing is not enough. Subversions on May 14-15 and 16-17 are at very different heights. Was vertical resolution at inversion height comparable?

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."

4. **p.6 l. 17 "to avoid numerical issues" really? Or data from dropsondes represent actual realization along trajectory, not a good choice for initial profiles?**

Our wording "avoid numerical issues" was obviously confusing. We meant, that we are simulating with a very high resolution, which is numerical expensive. The record of a dropsonde is higher in time and in space and thus we have many more vertical levels than in the model. Also because of the horizontal drift of the dropsonde through cloud inhomogeneities the profile is not monotonically. This caused issues in the model initialization and had to be smoothed out.

The dropsonde data are the only information we have from the atmospheric conditions during the campaign and it is a good choice to define the atmospheric BL, because of the high vertical resolution. The aim of the measurement flights during VERDI was to have similar conditions in a specified sector, where e.g. the cloud top height is the same over a certain area.

"The dropsonde are partly affected by horizontal variability, when slowly passing the cloud and drifting horizontally. *Therefore parts of the original profiles (Fig.2) are smoothed and brought to a vertical monotonic increasing profile for initialization of the model."*

5. **p. 7 l. 12 WD in Fig 4 I guess is for wind direction, but generally the figure is hard to interpret. E.g. the same wind shear whether in the middle of the given colour and at the edge of colours can be visible or not. I fill not comfortable with this plot.**

The reviewer is right. Figure 4 was hard to interpret. However, in the resubmitted version of the manuscript we removed Fig. 4. For the discussions of the wind direction we now use the extended plot in Fig. 2.

"The simulation of the 16 May shows a wind shear from around 150° to around 100° (Fig. 2) and a decrease of v with height above the cloud top height, which is also seen in the dropsonde profiles (Fig. 2c). The other simulations do not show a turning of the wind directly above the inversion height."

"Figure 2d and Fig. 2h illustrate the temporally averaged wind directions in the simulations."

6. **Section 4.2 The section shows nicely discrepancies between the experimental data and the simulation. Why in conclusion do you not call for higher resolution simulations? In the supplementary material of the paper you cite (Pedersen et al., 2016) there are suggestions that basic cloud patterns are reproduced reasonably in smaller domain. Why do you not perform sensitivity analysis due to model resolution?**

As replied to the reviewer's first comment, in the resubmitted version of the manuscript, we included a sensitivity study with respect to the model grid spacing. All relevant changes in the manuscript are given in our answer to the reviewer's first comment

7. **Section 4.3 Again: your model domain larger than the swath of the measurements. Why not to run model in smaller domain but at higher resolution? In particular when you conclude that the decorrelation length increases with decreasing spatial resolution.**

Thanks for this suggestion. As explained above, we added simulations with a higher resolution of 50 m by reducing the grid points. Additionally, we tested a further increase of the resolution. However, due to numerical instabilities, it was not possible to further increase the grid spacing. Please find the changes in the manuscript related to this comment below our answer to the first reviewer comment.

8. **Section 5.1. I think that your conclusion that the model captures temporal changes of inhomogeneity is not well justified, there are only 4 points analyzed. Moreover, the maximum modelled inhomogeneity is dated May 16th, while is observed on May 14th. On these days, vertical profiles indicate that clouds and boundary layer properties on these days are substantially different.**

Maybe it was misleading that we talked about a trend, which might lead to the impression that we compare the changes of ρ_τ on a temporal scale. In making this comparison, our intention was to show that in general COSMO produced larger/lower inhomogeneity, when larger/lower inhomogeneity was observed by the measurements. To avoid a further confusion, we rewrote this part by the following:

"However, the observations show that the cloud field became more homogeneous from 14 to 15 May as indicated by lower values of ρ_τ, which reduce from 0.209 to 0.115. From 15 to 16 May, ρ_τ increases to 0.145, which indicates a cloud field with slightly higher inhomogeneity. Then, on 17 May, ρ_τ reduced to 0.132, showing that the cloud field became more homogeneous again. These different cases with high and low ρ_τ are reproduced by COSMO independent on the chosen spatial resolution. Larger discrepancy between modeled and observed inhomogeneity parameters only occurred on 14 May, when the observations were influenced by large–scale cloud structures. Nevertheless, the lower/higher inhomogeneity is also imprinted in the inhomogeneity parameters S_τ and χ_τ, which are smaller/larger in both, measurements and simulations, indicating that COSMO performs well with regard to the 1D inhomogeneity parameters."

9. **Section 5.2. Results in this section are more convincing. However, these results could be strengthened discussing dynamical patterns (convective rolls) the boundary layer. Does the maximum optical thickness correlate with location of updraughts and maximum cloud top heights? Analysis of that could help to publish the paper, since conclusions are weak and should be supported with additional investigations; which can increase our understanding of modelled processes. This is particularly important in terms of your sensitivity study in Section 6.**

The reviewer is right. A more though rough investigation of the dynamical patterns of the clouds detected in the boundary layer will help to strengthen the results of the manuscript. Unfortunately, larger scale dynamic patterns such as role convection are not fully covered by the narrow view of the AisaEAGLE imaging spectrometer. Therefore, such analysis as suggested by the reviewer would only be possible using the simulations with COSMO. As this would not be very convincing without the observations, we, therefore, focus on the small-scale structure of cloud inhomogeneities.

Anyway, thanks for this suggestion! It is indeed possible using the methods applied in the manuscript to study larger scale dynamic patterns and might be done in a follow up study.

"Thus, also large–scale cloud structures are covered by COSMO (purple stripes in Fig. 4d) but not in the observations. Therefore, the large–scale structures cannot be compared between observations and simulations. With respect to a comparison of the small–scale structures, the spatial sizes (spatial resolution, domain size) of both datasets need to be conformed to make a direct comparison possible."

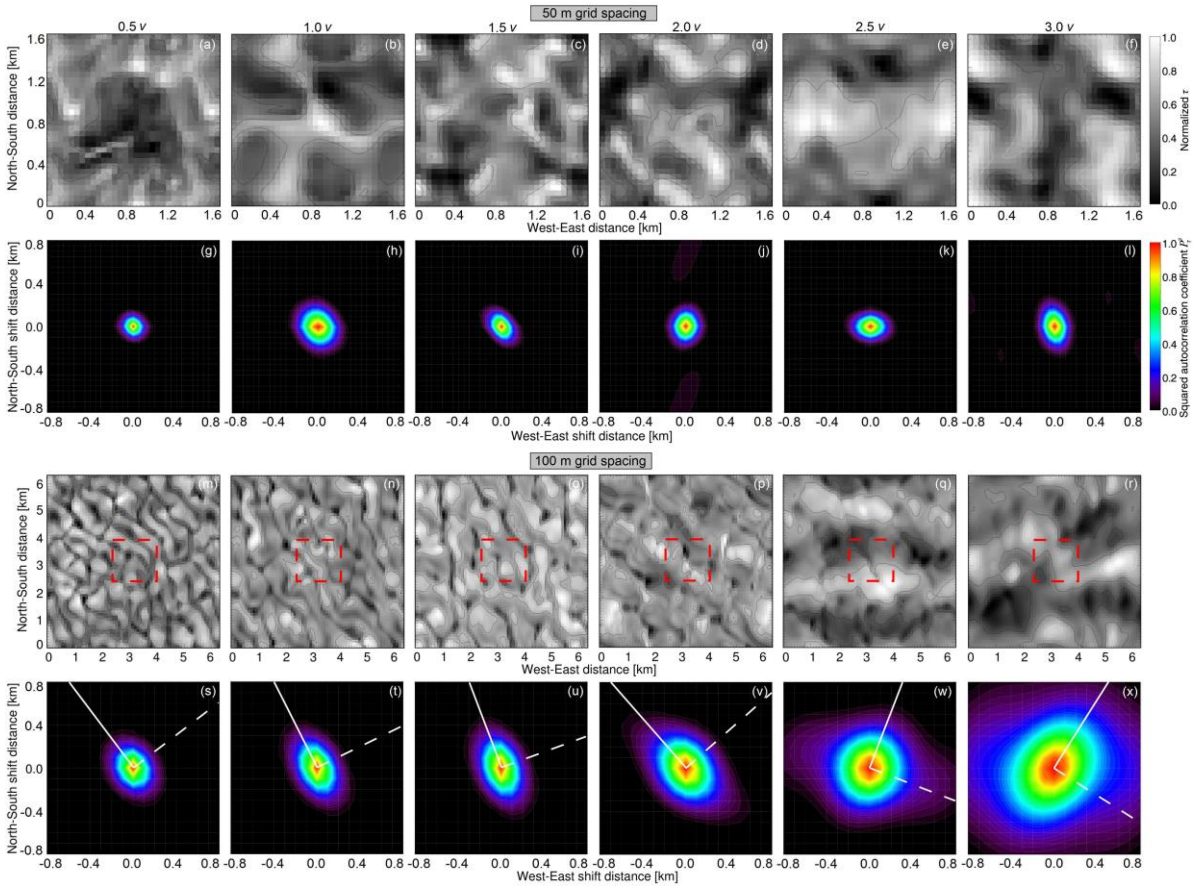
"Figure 4e and Fig. 4f further illustrate that it is not possible to compare the large–scale structures between observations and simulations. The large–scale structures, which are covered by the COSMO simulations are identified by a second increase of the $P^2_{\tau,sim}$ at distances ($\approx$1 km in Fig. 4f) larger than ξ_τ. The width of the measured fields is too narrow to cover such a second increase in the $P^2_{\tau,meas}$ (compare Fig. 4e). Therefore, the further comparison of the cloud structures, which are identified in the observations and simulations, is restricted to the small–scale cloud structures with sizes below 1 km only."

"The statistical methods applied in this study can also be applied to characterize the larger-scale dynamic patterns, if the domain is large enough to resolve them."

10. **Section 6. Again: this section calls for more thorough analysis as pointed above.**

By including simulations with 50 m grid spacing and the following discussion comparing different resolutions, we hope some interesting new results did now improve the manuscript. Comparing the results for the small domain (1.6 x 1.6 km) with the large domain (6.4 x 6.4 km), a major conclusion is that the small-scale structures simulated by COSMO must be influenced by the large-scale structures. This results from the fact that the small-scale structures depend on the wind speed (see graph below), when the domain is large enough so that large-scale structures can evolve. Contrarily, in the small domain, where no large-scale structures evolve, the small-scale structures are independent on changes of wind speed. Therefore, the effect of wind on the small-scale structures (Fig. 8s to Fig. 8x) acts only indirectly via the change of large-scale cloud structures. This has the consequence that the natural behavior of the small-scale structures (e.g. their size and orientation) might be disturbed, if the simulated domain is too small.

In the resubmitted manuscript, we extensively elaborate those new findings. Please find below our main changes to the manuscript and the revised Fig. 9 (now Fig. 8).



*“**Figure 8.** Exemplary selected fields of τ_{sim} for the 15 May 2012 case simulated for differently scaled initial wind speeds on a grid with 50 m spatial resolution and 1.6 km by 1.6 km domain **(a-f)** and on a grid with 100 m spatial resolution and with 6.4 km by 6.4 km domain **(m-r)**. Calculated 2D autocorrelation coefficients $P^2{}_{\tau}$ are given for each case in **(g-l)** and **(s-x)**. White lines in (s)--(x) illustrate the orientation used for the calculation of the 1D $P^2{}_{\tau}$ along (straight white lines) and across (dashed white lines) the dominant directions illustrated in Fig. 10. Red squares in (m)–(r) mark areas of comparable size to the small domains in (a)–(f).”*

“To test its influence on the horizontal cloud inhomogeneity, the simulations for 15 May (50 and 100 m grid spacing) are repeated for different initializations, where the wind profile is varied. Here, the case on 15 May is chosen, because it shows the best agreement between observations and simulations (Fig. 7r) to serve as a benchmark case.”

“Figure 8a to Fig. 8f show the simulated 2D fields of τ_{sim} for the simulations with the domain size of 1.6 km by 1.6 km and 50 m spatial resolution. Small-scale structures (< 0.5 km) are obvious and rather randomly orientated throughout the simulations for all six different initializing wind profiles. The spatial sizes of the small–scale structures quantified by the decorrelation length depend only little on the wind speed. This is confirmed by the 2D autocorrelation analysis illustrated in Fig. 8g to Fig. 8l. Displayed are only the horizontal scales below 0.8 km, quantified by the 2D autocorrelation coefficients for shifts below +/-0.8 km. A predominant direction of the small–scale structures is only slightly developed and varies independently from cases to case without clear preference. Furthermore, the $P^2{}_{\tau}$ and the decorrelation length, which vary between 150 and 300 m show only slight variations with changing wind speeds. This means that the sizes of the small–scale structures is basically independent to the wind speed.
Contrarily, the simulations with a domain size of 6.4 by 6.4 km and 100 m spatial resolution show a clear dependency on the wind speed. […]”

"Comparing the simulations for the small domain (1.6 x 1.6 km, 50 m spatial resolution) with the large domain (6.4 x 6.4 km, 100 m spatial resolution), indicates that the small–scale structures are most likely influenced by the large–scale structures. Only for the simulations with the large domain, the small-scale structures depend on the wind speed. This indicates that small–scale cloud inhomogeneities are not directly linked to the wind speed but rather are influenced by the large–scale cloud inhomogeneities such as cloud roles. If these large–scale structures are not covered by the simulations (too small domain), the natural behavior of the small–scale structures (e.g. their size and orientation) might be disturbed. With respect to the comparison between observations and simulations, this may explain why only on 14 May larger differences between model and observations were found. All other three cases did not show a significant large–scale cloud structure, while on 14 May cloud roles were observed by the imaging spectrometer. Thus, the simulations of 15, 16, and 17 May are more uncritical with respect to the model domain than for 14 May, when a large domain is required to reproduce the large–scale cloud structures and, therefore, improve the simulation of the small–scale cloud structures."

11. Section 7. After the additional analysis this section (and abstract) should be updated adequately.

Accordingly to the revised manuscript, we updated the abstract and Section 7 – Summary and conclusions. Please find the main changes below.

Abstract:

"[…] Simulations are performed for spatial resolutions of 50 m (1.6 km x 1.6 km domain) and 100 m (6.4 km x 6.4 km domain). Macrophysical cloud properties such as cloud top altitude and vertical extent are well captured by COSMO. Cloud horizontal inhomogeneity quantified by the standard deviation and one-dimensional (1D) inhomogeneity parameters show that COSMO produces more homogeneous clouds by a factor of two (100 m spatial resolution) compared to the measurements. Those differences reduce for the spatial resolution of 50 m. However, for both spatial resolutions the directional structure of the cloud inhomogeneity is well represented by the model. Differences between the individual cases are mainly associated with the wind shear near cloud top and the vertical structure of the atmospheric boundary layer. A sensitivity study changing the wind velocity in COSMO by a vertically constant scaling factor shows that the directional small–scale cloud inhomogeneity structures can range from 250 m to 800 m and depend on the mean wind speed, if the simulated domain is large enough to capture also large–scale structures, which then influence the small–scale structures. For those cases a threshold wind velocity is identified, which determines when the cloud inhomogeneity stops increasing with increasing wind velocity."

Summary and Conclusion:

"[…] For the reason of comparability, the observed fields of cloud optical thickness τ_{meas} were aggregated to pixel sizes of 50 m and 100 m, the applied spatial resolutions of the individual simulations. The general inhomogeneity was compared using 1D inhomogeneity parameters. For 100 m spatial resolution the absolute values of cloud inhomogeneity derived from COSMO are larger by a factor of about two, as compared to the values obtained from the observations. These differences slightly reduce, when the spatial resolution of the simulations is increased by a finer grid of 50 m. However, for both spatial resolutions the cloud inhomogeneity generated by COSMO is too low.
[…]
For the COSMO simulations with a spatial resolution of 50 m, the $\xi^{\updownarrow}{}_{\tau}$ and $\xi^{\leftrightarrow}{}_{\tau}$ agree well between observations and simulations, except for the case on 14 May. In contrast, for the simulations with a spatial resolution of 100 m, COSMO produced small–scale cloud structures with characteristic sizes 20 to 30 % larger compared to the observations. However, for both spatial resolutions the best agreement was found for the case on 15 May 2012.
[…]

The agreement between COSMO and observations for the case on 15 May 2012 is used as basis for a systematic sensitivity study with respect to the wind speed as a main drivers of the cloud inhomogeneities. Simulations for the case on 15 May with differently scaled initialization wind profiles showed that the degree of horizontal cloud inhomogeneity was not significantly changed for the simulations with a small domain (1.6 km x 1.6 km) and 50 m spatial resolution, but for the simulations using a large domain (6.4 km x 6.4 km) and 100 m spatial resolution. This indicates that the large–scale cloud structures such as cloud roles influence the small–scale cloud inhomogeneity. To correctly simulate the small–scale cloud inhomogeneity, COSMO needs to be run in a large domain, which also covers the large–scale cloud structures. This might have been the reason for the large differences between observations and simulations found for the case of 14 May, when pronounced cloud rolls were observed. All other cases did not show such large–scale cloud structures and were simulated by COSMO closer to reality despite the small domain.

[…]

Altogether, cloud inhomogeneities are a challenge for cloud resolving models. Not only the spatially averaged magnitude of inhomogneity but also the directional structure and the interaction with large–scale cloud structures needs to be reproduced in the simulations. Although COSMO produces more homogeneous clouds, it performed well, because it correctly represented the directional structures and the general degree of cloud inhomogeneity, if no larger–scale cloud structures are present. However, the statistical methods applied in this study can also be applied to characterize the larger–scale dynamic patterns, if the domain is large enough to resolve them.”