We thank the reviewer for the careful review and helpful remarks. As you can see, we answered all questions and comments. Our answers are:

Line 27.

In the phrase about 10(20) years there is no need in making a reference: it is just a reminder about the well-known fundamentals of statistical data analysis. To identify the regularities of variations in climate characteristics, which depend upon many processes on various variability scales, the length of observation time series should be many times (an order of magnitude or more) larger than the periodicity sought. For instance, to determine the character of the seasonal behavior, the length of observation time series should be of the order of 10 years. This will be shown later in our section 3.1, figure 6. However, under the conditions of reforming climate system, the statistical estimates may give a distorted or incomplete understanding of the studied process because of the new variability factors emerged. Taking into consideration your comment, we modified one sentence (Line 28-29) a little:
"However, under the conditions of changing climate system, a time series 10 years (or even 20 years) long may turn out to be insufficient to identify correctly the tendencies or periodicities in variations of aerosol characteristics".

Line 49.

You are probably right. The impact of the Kasatochi eruption on sun-photometer data only appeared short as the season of observations ended early Oct. We rewrote the sentence:

new

The effects of less powerful volcanic eruptions on the Arctic atmosphere are short-term to mid-term (some weeks in duration). For instance, AOD increase on Spitsbergen was observed after the eruptions of volcanoes Kasatochi (August / Sep 2008) and Sarychev (after July 2009) [Hoffmann et al., 2010; Toledano et al., 2012].

old

The effects of less powerful volcanic eruptions on the Arctic atmosphere are short-term (a few days in duration) and comparable to those due to smokes from forest fires. For instance, AOD increase on Spitsbergen was observed after the eruptions of volcanoes Kasatochi (August 2008) and Sarychev (July 2009) [Hoffmann et al., 2010; Toledano et al., 2012].

Line 142.
(a) *This phrase does not refer directly to Fig. 1, because it is in the next paragraph. Difference in the data from quasi-synchronous AOD measurements between two stations was already considered in our previous work [Kabanov et al., 2018] (see reference citation in Line 134), so only a conclusion is presented here. For more clarity, we gave the reference citation again in this sentence:*
"A comparison of the statistical characteristics showed that the average AOD values are a little larger in Barentsburg than in Ny-Ålesund [Kabanov et al., 2018]".

(b) *We think that it is a bad idea to display the average difference in the data between two stations in Fig. 1. But, if the Referee considers that this is mandatory, we prepared the following variant of the figure:*

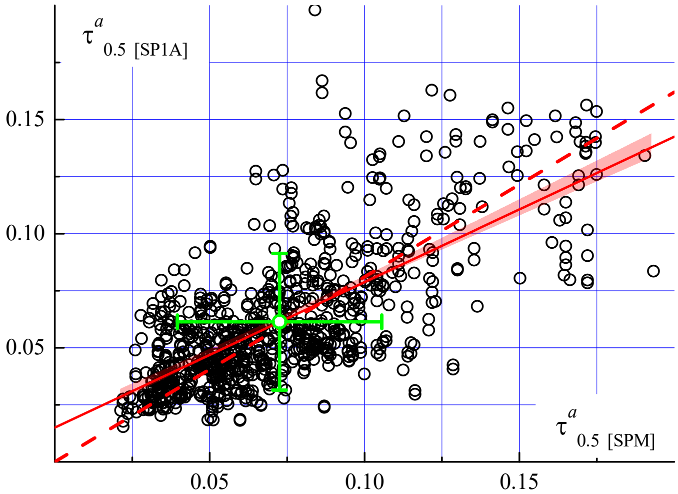

Fig. 1. Scatter diagram of AOD measurements in two regions using SP1A (Ny-Ålesund) and SPM (Barentsburg) photometers. Solid line: unconstrained linear regression; dotted line: regression through origin (0,0); green indicates the average value of the data difference and the standard deviation

Line 145. *Taking into consideration your comment, we modified one sentence (the word **error** was replaced by **uncertainty** and links were added):*
«At the same time, we note that the AOD differences are minor (comparable with uncertainty of determining AOD – about 0.01-0.02 [Kabanov et al. 2009; Sakerin et al., 2013]), and the interdiurnal AOD variations in the two regions are coordinated in character (correlation coefficients are 0.83-0.89)».

Line 148.
(a) *Yes - the Δ symbol indicates the average difference between the measurement data of two photometers (or AOD at two stations) at different wavelengths. This is not a measurement error, but the difference in physical characteristics in the two regions. The error (or rather, uncertainty) of the AOD measurements is 0.01-0.02 (see Line 145).*
(b) *Table 2 shows statistical characteristics on a completely different issue: standard deviations σ and correlation coefficients R between τ^c values calculated by different methods.*

Line 168. *Although Angstrom's formula is well known, we have added links at the request of the Referee:*
«Numerous studies in different regions and atmospheric conditions showed that the formula (1) does describe well the wavelength dependence $\tau^a(\lambda)$ in the main range (0.34 – 1 μm) of AOD measurements [Angstrom, 1964; Shifrin, 1995; Eck et al., 1999; Cachorro et al., 2000; Schuster et al., 2006].

1. Angstrom A. Parameters of atmospheric turbidity // Tellus XVI. 1964, N 1, p. 64-75.
2. Shifrin K.S. Simple relationships for the Angstrom parameter of disperse systems // Appl. Opt., 1995, Vol. 34, 4480-4485.
3. Eck, T.F., Holben B.N., Reid J.S., Dubovik O., Smirnov A., O'Neill N.T., Slutsker I., and Kinne S. Wavelength dependence of the optical biomass burning, urban, and desert dust aerosol // J. Geophys. Res., 1999, Vol. 104, 31333-31350.
4. Cachorro V.E., Duran P., Vergaz R. and de Frutos A.M. Measurements of the atmospheric turbidity of the north-centre continental area in Spain: spectral aerosol optical depth and Angstrom turbidity parameters // J. Aerosol Sci. 2000, Vol. 31, No. 6, pp. 687-702.
5. Schuster, G.L., Dubovik O., and Holben B.N. Angstrom exponent and bimodal aerosol size distributions // J. Geophys. Res., 2006, Vol. 111, D07207. doi:10.1029/2005JD006328.

Line 179.
The main point in this section was to show that the Ångström parameters are inconvenient for analysis of the causes for AOD variations. In particular, the parameter α depends on the relationship between two AOD components (τ^f and τ^c). Therefore, based on the parameter α, it is difficult to judge what (whether τ^f or τ^c) was the cause for the AOD variations.
The dependence of α on the components τ^f and τ^c is more complex and explicitly nonlinear in character. A variant of this dependence in the form $\alpha = \ln[(\tau^f_{0.5}/\tau^c) + 1]$ is presented in Fig. 2. Seemingly, a better approximation of this dependence can be selected; for instance, "a second order behavior of alpha" can

be used, as was done in the SDA method. However, this requires a separate study, and was beyond the scope of this paper. In this case, it was sufficient to show that α does depend on the relationship (τ^f/τ^c), and we did so (see regression in Fig. 2).

Line 191. *An explanation of the symbol P (confidence level) was added to this sentence:*
«The correlation coefficient between α and ln[(τ^f_λ/τ^c) + 1] is statistically significant and equal to 0.68 (confidence level P < 0.0001)».
"Confidence level P" is a standard and well-known statistical characteristic. Therefore, there is no need in providing a reference to any text-book.

Line 199. *In this sentence, we have added refinement (in troposphere):*
«The lifetime of fine aerosol in troposphere is a few days; therefore, it can be transported long distances (hundreds and thousands of kilometers) away».

Line 214. *You are right: the notation $\tau^f_{0.5}$ (τ^c) may be unclear. Therefore, in this sentence and in the text below we made the following correction: $\tau^f_{0.5}$* ***(or*** *τ^c). We clarify that, within different methods, the researchers calculate anyway a single component (either $\tau^f_{0.5}$ or τ^c), while the other is found as a residual of the total AOD (see Line 207-208).*

Line 217. *Thank you for your comment. We fixed the link* (*correct* – [Kabanov et al., 2019**a**):
«For the conditions of Arctic region (Spitsbergen), we performed an additional study [Kabanov et al., 2019a], concerning the selection of an optimal method of $\tau^f_{0.5}$ (or τ^c) estimation».

Line 221. *According to the Referee's comment, we added two clarifying sentences (see paragraph above):*
" … In the first regression method (RM1), τ^c is estimated using its interrelation with the parameter β (see formula (3) below). In the second method (RM2), the regression dependence of $\tau^f_{0.5}$ on the parameters α and β (see formula (4)) is used. Comparison of different methods …"

Line 228: *Thanks, we shifted the Table 2 and corrected the wrong layout.*

Line 230. *We added the link [Kabanov and Sakerin, 2016], as suggested by the Referee*:
«The disadvantage of the regression methods is that they require a preliminary data accumulation under the conditions of a specific region for determining optimal regression coefficients in equations (3) and (4) [Kabanov and Sakerin, 2016]».

Line 238.
It is not quite clear which part of the IM1 method is requested by the Referee to be described in a more detail. We will try to do so, but before we will give three clarifications.
1. In implementing IM1 (or IM2) it is entirely immaterial which (Sviridenkov's or another) method of solving the inverse problems is to be used. A large number of methods have been developed in the last half-century to retrieve the particle distribution functions from spectral measurements of AOD or aerosol extinction coefficients. That is, any accessible and verified algorithm of solving the inverse problem, making it possible to determine the distribution function (dV/dr), or (dS/dr), will be appropriate.
2. It is immaterial what (whether dV/dr or dS/dr) should be retrieved, because an interrelation with the optical characteristic, τ^f or τ^c, can be found for any of them. In addition, (dV/dr) and (dS/dr) are interrelated mathematically (either can be calculated if the other is known). Therefore, only one characteristic, (dV/dr), will be used below.
3. In this work, we used the (available to us) Sviridenkov's algorithm of solving the inverse problem, which is a modification of the Twitty algorithm. The algorithm of the (now died) Sviridenkov M.A. has been tested and successfully used for as long as 20 years by a few scientific groups from Russia.

Because you encountered problems with the reference to the work of Sviridenkov, we asked our Editorial office to make this issue (No. 12, 2001) of the Journal publicly available. We note that the results, obtained using the Sviridenkov's algorithm (as a part of the IM1 and IM2 methods), well agree with the data from other techniques (EM, RM1, RM2, and SDA). Therefore, we have no grounds to not trust the Sviridenkov's algorithm.
Using the IM1 method as an example, we will explain the consecutive steps of its implementation.
1st step. Based on any known method of solving the inverse problem (for a specified refractive index, type of the particle distribution function, and grid of radius ranges), the spectral AOD values are used to calculate the particle distribution function (dV/dr) or (dS/dr).
2nd step. In the distribution (dV/dr) thus obtained we select its part referring to the fine (submicron) fraction, and, for it, calculate the total particle volume (V^f) through integration. The size (radius) integration limits for particles in the fine fraction are: left boundary is specified depending on specific features of the chosen inversion algorithm (usually $r \approx 0.1$ μm); and 0.4 or 0.5 μm is taken as the right boundary.
3rd step. We consider the regression interrelation between particle volumes in the fine fraction (V^f) and the τ^f values, calculated by the empirical method (EM). The interrelation thus obtained (Fig. 4a) is used to select the parameters of a linear regression equation which makes it possible to calculate the component τ^f according to the particle volumes V^f. (Figure 4b illustrates the comparison of τ^f values, obtained by the two (EM and IM1) methods).

Taking into consideration the Referee's comments, we provided the text about the IM1 method in a little more detail (two insertions):
(1) "This method is implemented in the following steps.
1st step. Based on any known method of solving the inverse problem (for a specified refractive index, type of the particle distribution function, and grid of radius ranges), the spectral AOD values are used to calculate the particle distribution function (dV/dr) or (dS/dr).
2nd step. In the distribution (dV/dr) thus obtained we select its part referring to the fine fraction, and, for it, calculate the total particle volume (V^f) through integration.
3rd step. We consider the regression interrelation between particle volumes in the fine fraction (V^f) and the τ^f values, calculated by empirical method (EM). The interrelation thus obtained (Fig. 4a) is used to select the parameters of a linear regression equation which makes it possible to calculate the component τ^f according to the particle volumes V^f".
(2) "The inverse problem on retrieving the distribution functions (dS/dr) was solved using iteration algorithm of M.A. Sviridenkov [Sviridenkov, 2001], modified from Twitty algorithm [Twitty, 1975]. The particle distribution was assumed to be lognormal, and the refractive index was assumed to have the real part of 1.5 and the imaginary part of 0. In the calculations we used the following radius grid: 0.09-0.13-0.17-0.21-0.25-0.29-0.33-0.37-0.41-0.45-0.49-0.53-0.59-0.65-0.81-0.99-1.21-1.59-1.81-2-2.5-3 μm".

Line 256. *Thank you, corrected!*