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Interactive comment on "Post-processing to remove residual clouds from aerosol optical depth retrieved using the Advanced Along Track Scanning Radiometer" *by* Larisa Sogacheva et al.

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Dear Referee #2,

Thank you very much for the attention to our manuscript. We considered your comments and made a lot of changes to shorten the discussion before the CPP method description, as you recommended. Discussion on cloud screening has been taken out from the manuscript. We emphasized the focus of the manuscript on the AOD post-processing, related to possible cloud contamination in the retrieved AOD. We implemented your specific corrections, which helped to improve the manuscript.

Interactive comment on "Post-processing to remove residual clouds from aerosol opti-

cal depth retrieved using the Advanced Along Track Scanning Radiometer" by Larisa Sogacheva et al. Anonymous Referee #2 Received and published: 29 September 2016

General comments This paper presents an update to the post-retrieval cloud contamination method for satellite aerosol retrievals (and the ADV/ASV AATSR algorithm in particular) presented previously by Kolmonen et al. (2015). This update essentially involves a simple threshold test on the proportion of high AOD values retrieved in a region, with high-AOD regions not having the Kolmonen tests applied. This rather simple test, although it has a significant impact on the resulting ADV/ASV aerosol product, is not particularly interesting in a scientific or retrieval theory sense. The paper is essentially an addendum to the previous one and one is left wondering how a 13 page paper has been spun-up from it. Indeed, the reader has to plow through about 8 pages of reiteration of already published work before reaching the new work presented by this paper. I would like to see a significantly streamlined and shorter paper, focusing on the changes made from the methods and products described by Kolmonen et al. and showing some summary plots of the resulting improvement to the ADV/ASV product.

Ans:Following the Referee #2 and #3 recommendations, the paper has been shortened. The focus on the AOD post-processing has been emphasized. The discussion on cloud screening approaches has been taken away, since the post-processing introduced is applied to the AOD distribution retrieved and may be recommended in AOD retrievals as additional to cloud screening. We re-wrote the introductions and revised other sections according the Referee comments. We also combined sections 2, 3 and 4; 6,7 and 8. Figures 11 and 14 have been deleted.

Thus my recommendation is that major revisions are required before this work can be published. This clearly puts me at odds with the already submitted review, so I have provided detailed suggestions and corrections for the paper in its current form below.

Specific corrections In the introduction the authors describe what might be described as traditional cloud masking - a series of empirical tests based on thresholds in radiance,

radiance ratios or spatial variability - as though this is the only approach used for cloud detection. This isn't true, as there exist other approaches, such as neural-network (or other machine learning techniques) or statistical approaches such as naive Bayesian fitting have also been used. The authors should acknowledge this fact, and, crucially note that these approaches also suffer from the same limitations as traditional threshold based techniques.

Ans:The discussion on cloud screening approaches is not very much relevant in that manuscript and has been taken away to shorten the paper. See the reply to General comments.

Additionally, the authors should mention that a lot of the difficulties encounter with cloud-masking are due to its inherently subjective nature - what is a perfectly adequate mask for one task may well provide far from ideal to for another (e.g. a cloud mask used for cloud retrieval needs to be sure it IS looking at cloud, while one for aerosol retrieval needs to be sure it ISN'T looking at cloud).

Ans:The discussion on cloud misclassification in aerosol retrieval is included.

I have a problem with the use of the word "plume" in describing regions of high AOD from section 5 onwards. An aerosol plume is a clearly defined aerosol stream with a identifiable source, such as a smoke plume from a fire. The authors use the word to mean a region with elevated AOD, which is potentially confusing. Please use a more appropriate name, like high-AOD region for instance.

Ans:We understand the Referee #2 and Referee #3 concerns and renamed "plume area" to "high-AOD area" or "high-AOD region".

Abstract - P01L08: Replace "much stronger than" with "much more strongly than".

Ans:This sentence is deleted

- P01L10: Not all cloud masking techniques rely on a test of empirical tests – for instance neural-net or naive Bayesian approaches. Thus, replace "consisting of several

tests. However" with "but". Ans:The discussion on cloud screening approaches has been taken away. See the reply to General comments.

- P01L13: Replace "shows such areas with locally enhanced AOD values" with "produces locally enhanced AOD values in such areas".

Ans:The sentence is deleted

Introduction

- P02L12: The Kaufmann et al. and Zhang et al. papers are both relevant to a now quite outdated MODIS product version (although it isn't clear from the papers themselves which "collection" they used). The authors might consider providing more up-to-date references, or at least acknowledging that MODIS products – including cloud flagging - have improved markedly over the past decade. Ans:We decided to keep the Kaufmann et al. and Zhang et al. papers, because we could not find any recent publication on estimates of cloud contamination to aerosol retrieval.

Ans: We added a reference to the more recent paper by Zhao et al. (2013) on the global survey of the effect of cloud contamination on the aerosol optical thickness and its long-term trend derived from operational AVHRR satellite observations.

- P02L22-L25: This section seems to be providing a list of attributes for an ideal aerosol remote sensing instrument rather than one for cloud-masking. . . I think the statements about how current instruments sadly fall short of the idea for aerosol retrieval are superfluous. Just note that the cloud detection approaches for different instruments make use of the differing capabilities of those instruments.

Ans:This section is re-written

- P02L32: Replace "refer to other methods" with "use other methods"

Ans:This section is re-written

- P02L32: Sentence starting "Sensors with narrow spectral channels. . ." is irrele-

vant.Remove.

Ans:This section is re-written

Section 2 - P04L16: Replace "The AATSR is a dual view instrument" with "The ATSRs are dual view instruments".

Ans:replaced

- P04L20: Pedantically, the 1.6 μm band is near-IR, not mid-IR.

Ans:corrected

Section 3 - P05L02: Why is the 0.865 μm band only used over the ocean?

Ans:The explanation is added in Sec.2

Section 4 - P05L16: The term "native pixels" is inaccurate, as the standard AATSR level 1 files (which I presume ADV uses as its input data) are regridded from the instruments native sampling to a regular 1x1 km grid using nearest-neighbour sampling. This is a particularly important distinction when talking about the forward view, where multiple 1km pixels may actually be filled by a single instrument pixel.

Ans:The term "native" is replaced with the "AATSR Level 1B"

- P05L24: I am confused by the reference to Press et al. (1992) here - how is "Numerical Recipes" a reference for the automated determination of cloud masking thresholds? The same question applies to P06L17.

Ans:We deleted the reference to Press et al. (1992) and added the reference to Robles Gonzàlez (2003).

- P05L25-P06L22 (Section 4.1): I think a bulleted or numbered list of the four tests would be clearer.

Ans:This section is re-written; sections 2 and 3 are combined

- P05L26: "Most clouds are cooler than the underlying surface. . .". Also, can the authors provide an indication of how sensitive this gross cloud test is? How big does the temperature difference have to be for the pixel to be flagged? What happens, for instance, over mountainous regions, where the surface can be expected to produce large variations in brightness temperature?

Ans:Since the focus of the current manuscript was on the developing the cloud contamination post-processing method, but not on the evaluation of the existed cloud screening in ADV, we shortened the ADV cloud tests description and refer to Robles Gonzàlez (2003) and Kolmonen et al., (2015), where the ADV cloud tests are introduced and discussed. Short discussion on cloud misclassification in "complicated" environments (e.g., bright surfaces, small cumulus clouds, thin clouds over dark surfaces,) is added to Introduction.

- P05L29: Replace "below threshold" with "below this threshold".

Ans:replaced

- P06L01: Is the test based on the difference in absorption coefficient of water vapour from 11 - 12 μm, or is it the emissivity of ice at these two wavelengths? I think you'll find it is the latter.

Ans:This test is based on the difference in absorption coefficient of water vapour. Cloud test description is shortened

- P06L03: "T = T11 - T12 is usually positive. . ."

Ans:deleted

- P06L20: "reflectance at 0.865 μm is higher than at 0.659 μm over vegetated areas".

Ans:corrected

- P06L23: Replace "native" with "Level 1B" (see comment for P05L16).

Ans:replaced

- P07L08: Replace "For the dual view instrument" with "For the imagery provided by adual-view instrument"

Ans:replaced

- P07L09: Replace the sentence beginning "The reason for the stereo effect. . ." with "In (A)ATSR Level 1B data the forward and nadir data are nominally collocated at a standard surface ellipsoid corresponding to sea level". Also replace "In case of a cloud, the forward. . ." with "In the case of a cloud located above a given surface pixel, the forward. . ."

Ans:replaced

- P07L10: Replace "while the nadir view already sees the cloud approximately 2 minutes later" with "while the nadir view sees a fully cloudy pixel".

Ans:replaced

- P07L11: Remove the two sentences starting "In the AATSR data. . ." and "Hence the foward view. . ." The forward and nadir views of AATSR are NOT collocated in time, they are spatially collocated at sea-level!

Ans:removed

- P07L17: "depending on the cloud shape and height". Also, "both nadir and forward views are used in ADV over land".

Ans:corrected

- P07L21: Reword sentence to reference Fig.3: "The AOD retrieved from the same test scene used in Fig. 1 and Fig. 2 is shown in Fig. 3".

Ans:Reworded, with replying to the comment by Referee #3

Section 5 - P08, first paragraph: The term pixel is now referring to the 0.1 degree

retrieval pixel, not the 1 km Level 1 pixel, right? Please explicitly state this, or use a different word/phrase for the level 2 retrieval pixels.

Modified to: "A cloud post-processing method has been developed for application to L2 AOD data (0.1°x0.1° resolution) to filter out retrieval areas which are potentially cloud-contaminated, i.e. include residual clouds not detected by the initial cloud screening (Kolmonen et al., 2016). The old CPP (ExCPP) method includes two tests to determine whether a L2 pixel (referred as "pixel" hereunder) might be cloud contaminated."

- P09L05-L10: The description of how a region of high-AOD (a "plume") is defined is rather confusing. There appears to be a single test applied - what fraction of retrieval pixels produce an AOD > 0.6, but the authors talk about multiple thresholds and a multi-step process. I think it would be clearer to state up-front that high-AOD regions are defined as areas where >40-

Ans:This paragraph is rewritten according to the Referee comment.

P09L13: Insert text "The thresholds for the number of cloud-free pixels. . ."

Ans: done

Section 6 - P11L05: I find the statement that level 1.5 AERONET data hasn't been compared against because "validation must be done with the best quality data" a bit of a cop-out. If the authors feel that using level 1.5 data might provide better coverage of high-AOD events, then they should try it, even if it cannot be considered a primary validation.

Ans:Aeronet Level 1.5 data might contain the cloud-contaminated pixels, which should not be used in AOD validation

- P11L06: Replace "retrieved AOD and AOD results..." with "retrieved AOD and AERONET results..."

Ans:replaced

C8

- P11L18-L20: The sentences beginning "There is a discussion. . ." and "The linear approximation of. . ." are superfluous. Remove them.

Ans:removed

- P11L22: Replace "Instead we present the mean AOD and AOD standard deviation in different AOD bins (fig. 8)." with "The binned AOD mean and standard deviation are also indicated in Fig. 8."

Ans:replaced

Section 7 - P11L28: Replace "entails changes in..." with "results in changes in..."

Ans:replaced

- P12L18: Delete the sentence beginning "Regions of interest shown in Fig. 12. . ." (the caption of the figure provides this information).

Ans:deleted

Section 8 - P13L06-L09: This paragraph ("Yearly AOD time series over land. . .") and theb associated Fig. 14 are redundant. I suggest they both be removed.

Ans:Removed

- P13L10-L14: Conversely, why is there no figure showing the comparison with MODIS Collection 5? Furthermore, why are the authors not using more up-to-date MODIS data (Collection 5.1 or 6)? Please add a figure, or remove this paragraph.

Ans:The paragraph is removed

Tables and Figures - Table 2: In the caption, note that nnnnn corresponds to ENVISAT orbit numbers.

Ans:corrected

- Table 3: The dotted style of the cell border lines in this table make it hard to read.

Ans:Changed to the solid style

- Figure 1: In the caption, define which bands have been used to produce the RGB image. Also, note that it is vegetation which appears read in this imagery, not land per se. Finally, the correct grammar is "ocean is coloured black", not "ocean is coloured in black".

Ans:corrected

- Figure 8: The individual plots in this figure are too small to clearly make out the binned-averaged AOD values and their associated error bars. Perhaps split the figure into separate figures for each region? Also, extend the 1:1 line to span the full plotting range (0-4, rather than 0-3).

Ans:Color map has been changed to make the binned averaged AOD values more visible. 1:1 line is extended

- Figure 10: The top two plots are multi-annual means, not yearly means. Also, define the seasons in the caption; is winter DJF?

Ans:The title for the top plots is corrected; season definition is added

- Figure 11: Is this figure necessary? It doesn't convey anything not obvious from Fig 10.

Ans:Figure 11 is deleted

- Figure 13: This figure is far too busy and confusing. It is extremely difficult to distinguish which coloured line corresponds to which region. Also, the caption needs to define exactly what is plotted in each panel.

Ans:We removed some of the areas from the Fig.12 (Fig.11 in the revised version)

- Figure 14: I think this figure is superfluous (see comment for P13L06).

Ans:Figure 14 is deleted

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