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Atmospheric Measurement Techniques Discussions

Interactive comment on "Characterization of dark current signal measurements of the ACCDs used on-board the Aeolus satellite" *by* Fabian Weiler et al.

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General comments

The manuscript is dedicated to the improvement of experimental data coming from the ALADIN lidar onboard the Aeolus satellite, which provides continuous measurements of atmospheric winds, aerosols, and clouds. The manuscript seeks to solve an important problem of identifying and fixing the experimental issue associated with the so-called "hot pixels" of the ALADIN's ACCD detectors. The authors suggest a method for pinpointing these pixels, introduce dedicated calibration modes, correct the signals from the affected pixels, and show the results of wind retrievals from the fixed signals.

The problems of this kind are not new to the experimental physics, but in this case the study was hindered by the fact that the experimental setup was not available for direct testing in the lab. Still, the authors show that it provided sufficient amount of information for performing the analysis and for fixing the problem. In general, the real state of the atmosphere and the retrieved atmospheric data are linked through a number of conversions and convolutions, each of which can affect the quality of the retrieved parameters. In the case under consideration, the biggest challenge was associated with the missing or damaged pieces of information, needed for the retrieval, namely, with pixels providing the profiles yielded from fringe-imaging or double-edged techniques in some ACCD rows.

Since the backscattered photons carrying the information about the atmospheric properties in this setup are stored in ACCD matrix, one can split the solution of the problem to several steps: (i) identifying the pixels, which are not reliable; (ii) correcting or excluding these pixels from the retrieval; (iii) depending on the previous choice, one has either use the fixed values or modify the retrieval algorithm; (iv) since the initial retrieval algorithm did not take into account the possibility of hot pixels spoiling the inputs, one has a right to impose physical constraints on the retrieved data to fix the affected points. The authors did an excellent job for (i) and then they followed the correction scheme of (ii) and ended up with (iii). From this point of view, the work is impeccable. Still, I'd suggest to consider a bigger picture and to look at the problem at a different angle. Perhaps, the authors did it in the background and found that it didn't solve the problem, but I found no trace of it in the manuscript, so at least this is worth a discussion.

Let me explain. Looking at Fig. 1 of the manuscript and comparing it with the Fig. 11, one can see that the experimental setup has a certain redundancy in a sense that the peak in the Mie signal almost never is narrower than 3 bins and, in some cases, a naked eye distinguishes 4 bins filled with non-zero signal. At the same time, Fig. 11 tells us that the situations when two adjacent horizontal pixels are "hot" are rare. Knowing that this detector is characterized by a low noise, one can make use of the remaining available information and still get a reliable result. To prove this, I performed a simple test illustrated in the attached Figure. The panel (a) shows the Mie detector mask, which is consistent with Fig. 11 of the manuscript, but converted to a binary (good/bad) form. Panel (b) shows the simulated signal, which qualitatively resembles that of Fig. 1 of the manuscript, but which passes through the hot pixels of the mask (a) for demonstration purposes. For each row, the exact position of the peak corresponding to exact value of the wind is stored for reference. Panel (c) shows the same signal with hot pixels masked out. The Poissonian noise was added to the pixel values to imitate the detector's behavior. Then the fitting procedure based on sliding profile correlation approach similar to those used in [Goldberg et al., 2012] and [Feofilov and Stubenrauch, 2019] was applied both to a full set of input data and to a masked one. The procedure uses the knowledge of the profile of the fringe-imaged signal along the columns and this profile is supposed to be known with high accuracy. The resulting retrieval uncertainties are shown in panel (d) of the Figure. As one can see, the position of the peak retrieved from incomplete data does not change that much compared to the retrievals from the unmodified datasets, and the uncertainty in pixels converted to wind speed uncertainty is of the order of 0.03 m/s. This is just a rapid exercise, which should be done in a different way for Rayleigh signals, but it leads to an important question – even though the fixed hot pixels provide a dataset compatible with the rest of the processing chain, wouldn't it be easier and safer to exclude them from the consideration and to update the procedure? I understand that this is not what the manuscript is about, but it's a major philosophic question whether one should use fixed values from a damaged detector or use a reduced dataset profiting from the redundancy of the data. The latter approach does not diminish the significance of the work, but if it proves to give more reliable data through a simpler procedure, it should be considered.

The second question is about aforementioned step (iv) – I believe, the retrieval procedure could profit from the physical constraints of the following kinds : (a) point-to-point wind speed change and (b) point-to-point aerosol/cloud properties change. Both are

easy to justify and both can serve as an additional quality control mechanism at early stage – if sudden unphysical jumps are found, the pixels are removed from the retrieval and the values are interpolated, masked, and so on.

I have chosen "minor revisions" in the decision, but I'd like to see these questions addressed in the final version of the manuscript as well as the specific comments below.

Specific comments

Lines 200-209: if CIC noise is important, how does this fact match the "low-noise detector" statements above? Some numbers are needed here, so that the reader could make his/her own conclusions.

Line 278: can one prove this statement about the DUDE correction with some formula or reference? At the moment, there are only qualitative statements here.

Lines 300-320: perhaps, it's a matter of preferences, but how does this approach compare to a simple 3-sigma test? Another approach, which could be also useful for detecting hot pixels as well as identifying the nature of the noise is building and analyzing Fourier spectra of the temporal sequences for each pixel. Most probably, the spectra of hot pixels will be different from those of "normal" ones and hot pixels of a different nature will reveal this in the spectra, too.

Line 338: again, spurious changes could have been filtered out by Fourier smoothing procedure

Lines 400-410: see the general comments – perhaps, the discussion should be updated.

Lines 430-435: how does this correction compare to vertical interpolation?

Line 439: a median correction is applied, which does not eliminate sporadic events. Even though it smooths them out, their erroneous nature is included in the results. On the other hand, gradient-based or Fourier filtering would have removed a non-physical part of the signal.

Line 500: it would be interesting to recalculate these 6% into a weighted percentage of pixels used in retrievals. For example, pixel [9,13] is used often whereas [1,1] is not.

Line 550: Linear trend is interesting here. If the damage is due to high energy particles hitting the ACCD then the slope should change with time, but 6% is too small a number for this to be noticed.

Line 689: cosmic particles partially penetrate the atmosphere, so this is not a 100% proof.

Lines 701-702: first, we did not see this in the manuscript and second, it should be considered in the light of the exercise demonstrated in General comments.

Line 752: numbers are missing here: uncertainty/bias after the correction vs uncertainty/bias before the correction.

Technical corrections

Lines 301, 342, and elsewhere – in some PDF viewers, the font used for Python module names looks strange.

References

Feofilov, A. G. and Stubenrauch, C. J., "Diurnal variation of high-level clouds from the synergy of AIRS and IASI space-borne infrared sounders", Atmos. Chem. Phys., 19, 13957–13972, https://doi.org/10.5194/acp-19-13957-2019, (2019).

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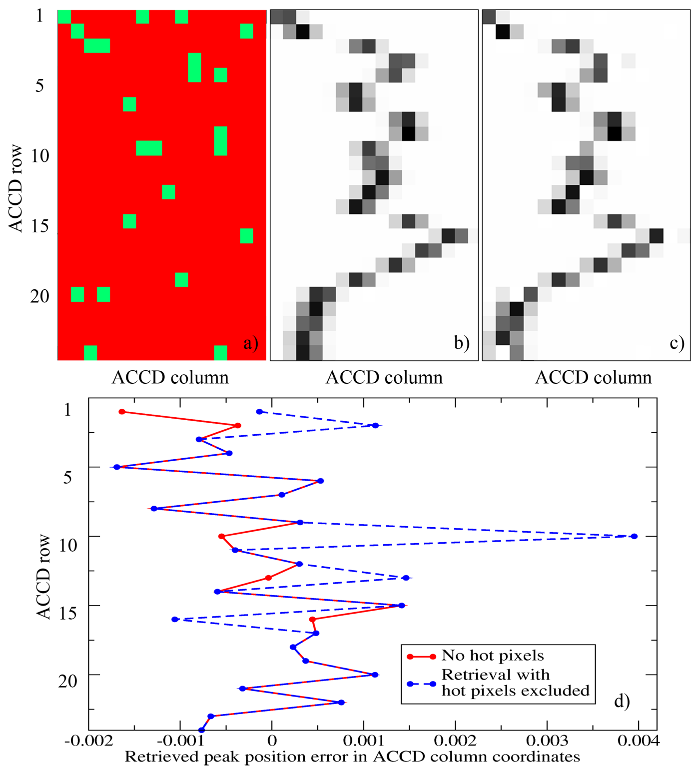

Fig. 1.