Interactive comment on "Increased aerosols content in the atmosphere over Ukraine during summer 2010" *by* Evgenia Galytska et al.

Evgenia Galytska et al.

egalytska@iup.physik.uni-bremen.de

We thank the Referee 2 for the detailed and constructive comments, valuable advice which we believe improved the quality and readability of our manuscript. We address the suggested improvements below in blue. The notation is as follows: P1 L12 means page 1, line 12.

The manuscript by Galytska et al. attempts to describe the impact of ïňĄres on the aerosol loads over Ukraine in summer 2010 using a combination of ground and space based remote sensing data. To my opinion the work would be more suitable for 'Atmospheric Chemistry and Physics' journal rather than for AMT. In fact, it analyses

and discusses data, but does not provide or use any new 'measurement technique'. That said, I also believe the manuscript is not mature enough for publication and needs major revisions.

We thank the Referee for these comments and we agree that we do not provide any new measurement technique in our research. Although, to our opinion, our research fulfills and covers the subject area of AMT, one of which is the intercomparison of measurement instruments. Our research mostly comprises detailed description of applied methodology of data comparison between satellite and ground-based measurements and explanation of achieved results. Provided explanations of physical/chemical processes that occurred in the atmosphere during summer 2010 over Ukraine and Eastern Europe are present, but do not dominate in our research. Thus, we considered to submit this paper to AMT.

Main drawbacks are: 1) Lack of novelty, or at least lack in communicating the novel aspects of the study with respect to the abundant literature on similar aspects of the same fires episodes. 2) Length of the text and use of language both contributing making the reading difficult.

The authors need to make an effort to synthesize the information, focussing on the main aspects of novelty they believe this work contributes highlighting.

We completely agree to the Referee and reworked and reorganized the manuscript to highlight its novelty, reduced its length by restructuring methodological paragraphs, optimized the titles of Sections 2 and 3 to better address the sections subject. We have also shortened Sections 3 and 4 by generally more focussing on our major findings and their interpretations.

Additional General comments:

- Please use either PAST TENSE or PRESENT TENSE, do not mix the two.

We thank the Referee for having drew our attention on this. We have corrected the manuscript with past tense where appropriate.

- Please introduce the acronyms the first time you use them or insert a list at the end of the manuscript (e.g., ETR, AOD, AERONET, WMO, SSA. . .)

All acronyms have been spelled out the first time used. Thank you.

- Full sentences taken from other papers should be quoted.

Thank you. We quoted full sentences which were taken from other papers.

- I would suggest to use the term 'comparison' rather than 'validation' for the satellites vs AERONET cross analysis.

Thank you. We have replaced the term 'validation' with 'comparison' all over manuscript.

- List of references is often not given in the correct format.

We thank Referee 2 for the comment, although, we are not sure we recall this comment

correctly. We revised the references, added missing parentheses in citations all over the manuscript. We also have revised bibtex citations. We hope, with this we could fulfill the request of Referee.

- As already mentioned, the language should be improved. Some examples are given in the list of specific comments below. However this should not be considered exhaustive.

We agree to the Referee. We have critically revised entire manuscript, carefully revised the grammar. We re-read the manuscript after all modifications, checked the application of definite/indefinite articles with nouns, corrected manuscript with the past tense, did not pluralize nouns (e.g. aerosol). Also, English has been proofread.

Additional speciïňĄc comments:

Abstract.

Line 5. Use 'plus MODIS ..' rather than 'and MODIS..'

We have corrected 'and MODIS' to 'plus MODIS' P1 L6. Thank you.

Line 8. The term 'air pollution' seems too generic here.

We have corrected 'the highest air pollution' to 'the highest aerosol content'. P1 L9.

Line 9. The term 'combustion center' is misleading, it could be rather replaced by 'fires' (the same all over the text).

We have replaced 'combustion centers' with 'fires' all over the manuscript. Thank you.

Line 11. 'Were' should be 'was'.

We have rewritten the sentence from passive to active voice as follows: 'We analyzed aerosol spatio-temporal distribution over Ukraine using MODIS AOD 550 nm and further compared with the Kyiv AERONET site sunphotometer measurements;...'. In reworked manuscript it is P1 L13-14.

Line 16. Single scattering albedo is not a microphysical property.

We agree with the comment and rephrased the sentence as follows 'We estimated the influence of fires on the spectral SSA, size distribution, and complex refractive indices using Kyiv AERONET measurements, performed during summer 2010'. Please, check P1 L16-18.

Line 18. Please specify better what you mean with 'highest' when talking about 'aerosol pollution'.

We have improved the wording in this sentence and have replaced ' highest aerosols pollution' with 'maximum AOD' as follows: 'In this study we showed that the maximum AOD in the atmosphere over Ukraine recorded in summer 2010 was caused by particle transport from the forest fires in Russia'. P1 L19-20.

Introduction

Introduction is too long and should be rewritten. Now it is rather a long list of short summaries from each single previous study on the same matter. From my point of view, the Introduction should be rewritten so to report a synthesis on what we do know and not know from previous studies, the latter (presumably) driving the motivation for the current work. Then the novelty of this work with respect to these previous studies should be clearly mentioned.

We agree to the Referee and have rewritten the Introduction entirely. Now it is structured as follows:
- Short introduction into importance of wildfires as a global source of aerosol.
- Description of importance of wildfires events during summer 2010. We have addressed here to previous studies (in chronological order) devoted to aerosol dynamics over the European territory of Russia (ETR) and Eastern Europe. Also, we have highlighted the papers of aerosol research performed for the territory of Ukraine.
- Explanation of the contribution and novelty of our research in comparison with other works, its driving motivation.
We have made suggested changes on P2 L2-P4 L11 in the reworked manuscript.

Page 2 line 5. Insert references at the end of such a general statement.

We have completely withdrawn this sentence.

Page 2 line 9. Remove 'are' at the end of the line.

We have completely withdrawn this sentence.

Page 2-3. Description of the results by Konovalov et al. (2011) is too long (16 rows) and should be shortened focussing on the major findings.

We have rewritten and shortened the description of the results by Konovalov et al. (2011), focussing only on the major findings as follows : 'For example, Konovalov et al. (2011) analyzed the evolution of near-surface concentrations of carbon-monoxide, PM10 and ozone in Moscow region by comparing ground-based and satellite measurements with the modified version of the multi-scale chemistry-transport model for atmospheric composition analysis and forecast CHIMERE, http://www.lmd.polytechnique.fr/chimere/. They used fire radiative power data re-trieved from Moderate-Resolution Imaging Spectrometer (MODIS) on board National Aeronautics and Space Administration (NASA) Aqua and Terra satellites to study the spatio-temporal variability of the fires. They also used MODIS AOD 550 nm to correct a negative bias in fire radiative power measurements in case if fires obscured by heavy smoke. They found that "...extreme air pollution episodes in Moscow were mainly caused by fires taking place at relatively short range (less than 200 km) from Moscow; the transport of air pollution to Moscow from more distant fires was less significant. It was also found that a compensation of a possible negative bias in the measured radiative power from fire obscured by heavy smoke is a crucial condition for a good performance of the model". Please, see P2 L14-23. Thank you.

A first Figure introducing the study area and all the main sites/regions referred to in the text should be inserted.

Thank you, we have inserted the map with the study area and used AERONET observational sites in Eastern Europe and Ukraine. Please, see reworked manuscript Fig.1 on P5 and figure below.

Section 2.1

Page 4 Lines 8-9. This sentence is questionable and should be rephrased. I do not think it is a matter of rating best and worse remote sensing techniques.

We agree with the Referee and completely removed the sentence.

Page 4 Line 13. What do you mean by 'metrology' here?

We have withdrawn 'metrology' from the sentence. Reworked sentence looks as follows: "The basic principle of the network is to standardize the equipment, mea-surement techniques, and data processing, which are stored in a freely accessible centralized database'. P4 L16-17

Page 4 Line 20. Correct into (Holben et al., 1998)

Added parenthesis (Holben et al., 1998). P4 L24. Thank you.

Page 4 Line 21. Angstrom Exponent is used to describe the AOD spectral variability. It is not necessarily computed between 440 and 870 nm. Please clarify better.

We thank the Referee for raising this issue. It is recognized that there is often significant spectral variation of aerosol size distributions with an accumulation mode (Eck et al., 1999; O'Neill et al., 2000). In this paper we present only the 440-870 nm linear fit determination as a first-order parameter indicative of the general size distribution and the relative dominance of fine versus coarse mode particles (Holben et al., 2001). The 440–870 nm Angstrom is computed from linear regression of ln AOD versus ln λ scale at 440, 500, 675 and 870 nm (Eck, et al., 2009).

We have reworded and clarified this statements on P4 L24-28 as follows: 'The Angstrom exponent (AE) is also determined by the AERONET algorithm for the sunphotometer spectral range 340-870 nm from direct sun irradiance measurements. We used AE to interpolate the AOD on the required wavelength. We applied AE determined for 440-870 nm because it is suitable to the aerosol size distribution during wildfires when relative dominance of the fine mode particles takes place (Eck et al., 1999; Holben et al., 2001)'.

Page 4 Line 22. What do you mean with 'altitude circle'? Do you mean 'principal plane' measurements? Please clarify. Also insert a comma after 'Sun'.

We have completely withdrawn this sentence in the reworked version of manuscript.

Page 4 Lines 29-30. Please list here which additional AERONET sites in Eastern Europe you used.

We listed AERONET sites of Eastern Europe on P4 L29-32 as follows: 'To assess the extent of the impact of wildfires in summer 2010 we used data from the following Eastern European AERONET sites (also shown in Fig.1): Minsk (Belarus), Moscow

C9

(Russian Federation), Toravere (Estonia), Belsk (Poland), Moldova (the official name of the site is Moldova, although it is located in Chisinau, Moldova), Cluj-Napoca, Bucharest, and Eforie (all Romania). We also used data from the only two Ukrainian sites that measured during summer 2010: Kyiv and Sevastopol'.

Section 2.2

Page 5 Lines 8-9. Please rephrase.

We have completely withdrawn this sentence.

Page 5 Line 11. Please rephrase.

We have rephrased the sentence as follows: 'Over land, aerosol properties are retrieved from spectral channels 0.47, 0.66, and 2.12 μm. One of the primary aerosol products of the MODIS algorithms is the AOD at 550 nm in the atmosphere over land and ocean (Remer et al., 2005, 2008; Levy et al., 2007, 2010, 2013)'. P6 L7-9.

Page 5 Lines 14-16 . The MODIS product you used is obtained from both land and ocean MODIS algorithms, not just the land one. The fact that you only use land retrievals given the region under examination is a different thing. Please rephrase.

We agree to the Referee and have rephrased the sentence as follows 'To estimate atmospheric pollution over Ukraine caused by aerosol from wildfires, we used AOD at 550 nm retrieved by the land algorithm and collected in the MODIS Aqua and Terra Level 2 Collection 005 and 051 Optical_Depth_Land_And_Ocean product file'. P6

C10

Page 5 Line 27. This sentence should be rephrased as not clear in the current form.

We thank the referee for highlighting this issue. We have rephrased the sentence as follows: 'For comparably clean atmospheric conditions, when AOD is close to zero, AOD values in the range ±0.05 are practically indistinguishable (Remer et al., 2005, 2008; Levy et al., 2009). Following Levy et al. (2009), we set corresponding data in this range to zero'. P6 L20-22.

Page 5 Lines 33-34. The given link should not include a specific period as it is now.

We have completely replaced the link 'http://rapidfire.sci.gsfc.nasa.gov/cgi-bin/imagery/firemaps.cgi?period= 2010221-2010230' by 'https://firms.modaps.eosdis.nasa.gov/map/' as the 10 day global fire maps are no longer being produced. P7 L2. Thank you.

Page 6 Line 5. Should be just 'vegetation fires'

We have replaced 'under conditions of forest fires and other vegetation or peat' with 'wildfires' to be consistent all over the manuscript. P7 L7.

Section 2.3

Page 6 Line 12. Should be 'at nadir'

Corrected to 'at nadir'. P7 L14. Thank you.

Page 6 Lines 15-16. Should be 'CALIOP measurements allow to derive aerosol and clouds vertical distribution...' or something like that. Please rephrase. In the current form, the sentence is not fully correct.

We have rephrased current sentence in a more simple way: 'CALIOP measurements allow to derive the vertical distribution of aerosol and clouds'. Please, see P7 L18.

Page 6 Line 19. 'Were' should be 'was'.

We have rewritten the sentence from the passive to active voice as follows: 'For this study we used both parameters, vertical distribution of the extinction coefficient and AOD at 532 nm, defined along the path of the sub-satellite point'. P7 L20-21.

Section 2.4

Page 6 Line 27. 'on ' should be 'of'

We have corrected 'on' to 'of'. Thank you. P8 L15.

Page 7 Lines 1-2. Not clearly written. Please rephrase.

We have rephrased the sentence as follows: 'According Stohl (2002), the uncertainty of calculated HYSPLIT trajectories for a period longer than 24 hours is around 20

% in the horizontal direction in the free troposphere; after 120 hours the uncertainty increases to about 400 km in the horizontal and about 1300 m in the vertical planes'. P8 L26-28. Thank you.

Section 3

Methodology and Results should appear in separate Sections.

We agree to the Referee and we have reworded the titles of Section 2 and 3.
Section 2 has been renamed from 'Data sources' to 'Methods and data sources'. We aim to collect all relevant information about methods used in our study in a respective section. Section 3 has been renamed from 'Methodology and results' to 'Results and Discussion'.

Page 7 Lines 4-5. This is a repetition. Please remove.

Thank you. Removed.

Page 7 Lines 11-18. Please make this part shorter focussing on the main points affecting the way you can make use of the CALIOP dataset. Better explain which is your 'collocation' criteria for CALIPSO given the limitations described.

We have restructured the manuscript, and the description of methodology, in particular CALIOP comparison with other instruments, is now presented in Section 2.3, P7 L23-P8 12.

Page 7 Lines 18-19. Not clear. Please rephrase.

We have removed the entire sentence. Although, as mentioned in the previous reply, we have restructured the paper and moved the description of methodology regarding CALIOP to the Section 2.3.

We address these changes on P7 L23-P8 L12 as follows:
'A comparison of CALIOP AOD with ground-based AERONET observations can be challenging because of different measurement characteristics of both instruments. The CALIOP lidar provides only fragmentary data on aerosol along CALIPSO satellite's ground track, because of the small size of its light beam and cloudy conditions that frequently occur. Due to instrument's orbital period of 98 minutes, ground tracks of satellite consecutive passages at certain latitudes are shifted 24.5to the west, making its spatio-temporal coverage rather sparse. Consequently, the probability of CALIOP to pass over the atmospheric column observed by the solar photometer AERONET is also rather limited (e.g. Redemann et al., 2012). During the three summer months of 2010 we found no coincident CALIOP-AERONET measurements over Kyiv, apart from the single collocation, although not exactly matching the selection criteria according to Omar et al. (2013). In this case the closest CALIPSO ground track was found 60 km east from the Kyiv AERONET site.

Therefore, in this study we only compared CALIPSO/CALIOP CloudAerosol Layer Product AOD 532 nm (Winker et al., 2009, 2010) with MODIS/Aqua AOD 550 nm since the orbits of both satellites are in the A-Train afternoon constellation (http: //atrain.nasa.gov/). Relative positions of CALIPSO and Aqua satellites in the A-Train provide great number of practically simultaneous measurements with the time span of 2 minutes, while the spatial difference is only about 10 km. Each granule of MODIS data consists of consecutive scans across the satellite track. The footprint of CALIOP light beam on this granule looks like a sequence of points on the straight line, which are passing close to the center of a granule. Each of these points represent the center of

the CALIOP measurement averaged over 5 km and once or twice matches with one of the pixels of a MODIS granule. To find these matches we calculated the distances and azimuth angles between the center of each CALIOP point and the center of each pixel in MODIS granule in the same manner as for the MODIS-AERONET case, described in Section 2.2. We averaged MODIS data over areas 50 km × 50 km, while CALIOP data in the CALIPSO CloudAerosol Layer Product are averaged on the various distances along the satellite ground track, up to 80 km (see CALIPSO Quality Statements Lidar Level 2 Cloud and Aerosol Layer Products, Version Releases: 3.01, 3.02). We did not apply any correction for potential spectral differences while comparing CALIOP AOD 532 nm and MODIS/Aqua AOD 550 nm. This yields to an estimated systematic bias in our AOD comparison of approximately 2–6 % in the AE range between 0.5 to 1.8 (see Fig. 5b) and can be neglected in our cases, following Kittaka et al. (2011)'

Section 3.1

I think a better definition of the term 'summer' used throughout the text is needed. Isn't summer defined as June-July-August in your work?

We agree with the Referee's comment and defined summer 2010 as June 1-August 31 in the Abstract and Introduction.

Why do you limit the fires analysis in Fig 1 to the period 1 July- August 20?

We have followed the Referee's comment and reworked the Figure. Now this Fiure includes fires location and brightness temperature (in K) of fires pixels in Eastern Europe and the ETR (40–65N and 10–60E) from June 1 to August 31. Please, note, that in the reworked version of manuscript, this Figure corresponds to Fig. 2, not Fig. 1. Please,

C15

see updated Figure on P10 of reworked manuscript or below.

And why Fig 2 shows data from June 1 to August 24??

We have also reworked this Figure and its updated version covers total amount of the fire pixels for each day of summer 2010 from June 1 to August 31. Please, note, that in reworked version of manuscript, this Figure corresponds to Fig.3, not Fig.2. Please, see P11 or below.

Please clarify better the term 'summer 2010' since the beginning and try to be consistent with this in your Figures.

We agree with the Referee's comment and as mentioned before, we defined summer 2010 as June 1-August 31 in the Abstract and Introduction.

Please, show on Figure 1 the study area used in Figure 2.

We have followed the Referee's suggestion and in the reworked manuscript Fig.2 shows the study area used in Fig.3. Please note, that reworked figures differ from 'original' versions because we now used high-confidence data of brightness temperature of fire pixels. This means that the confidence level of calculated fire pixels is larger/equal 80%. In previous version of the manuscript we used all available data, which included low confidence data.

Page 8 Lines 1-2. Actually, given the large number of fires in Fig.1, it is not the best

C16

way to show 'fires concentration'. A metric like the number of fires per unit area should be rather used for this purpose. Either rephrase this sentence or modify Fig 1 accordingly.

We agree to the Referee and rephrased the the sentence. We replaced "the highest fire concentrations" in the following way: 'Both the overall number and the brightness temperature of fires reached their maximum between July 26 and August 18'. P9 L8-9.

Page 8 Line 3. If I understand correctly, FRP stands for Fire Radiative Power (please, provide acronyms). However, note that Fig 1 does not show FRP but T. Since these are different quantities, again either modify Fig. 1 or modify the sentence.

We have modified the the sentence and replaced "FRP" with 'brightness temperatures'. Thank you.

Table 1: From Table 1 (and relevant text) it is not clear to me which is the overall period considered to compute the values reported.

We have improved the caption of Table 1 (P11) to 'Level of air pollution caused by aerosol (AOD 500 nm) from June 1 to August 31, 2010 over the ETR and Eastern Europe according to AERONET' and improved the text on P9 L15-18 as follows 'We analyzed changes in AOD at 500 nm using all daily averaged measurements from June 1 to August 31 from the AERONET database from Minsk (Belarus), Moscow (Russian Federation), Toravere (Estonia), Belsk (Poland), Moldova (Chisinau/Moldova), Cluj-Napoca, Bucharest, Eforie (all Romania), Kyiv and Sevastopol (both Ukraine)'.

C17

Page 9 Line 5. Replace with 'for dates of maximum AOD'.

Change made. Thank you. P9 L23-24.

Page 9 Line 8- Page 10 Line 24. This part is too long and should be shortened.

We agree to the Referee and have slightly shortened part of the text. However, the aim of this description is to show that the maximum AOD values over analyzed AERONET sites were formed under conditions of transport of aerosol from the areas of active wildfires. Moreover, such a detailed analysis of the transport of air masses to the analyzed AERONET sites has not been performed in earlier studies for the days of summer 2010, when maximum AOD was observed. Revised text looks as follows:

'Back trajectories for Moldova and Belsk, where the maximum AOD was observed the earliest within summer 2010 (July 13 and 16, respectively), are shown in Fig. 4a,b. The trajectories indicate that aerosol was transported to Moldova at altitudes from 0.5 to 1.5 km from the fires in the ETR and south-east of Ukraine (see also Fig. 2d,e). Into the region of Belsk, aerosol was transported across continental Europe (1.5–5 km) mostly from the Atlantic Ocean, but also from the Baltic across regions of active fires (Fig. 2) in the lower atmosphere (500 m).

Transport of aerosol to two Romanian sites (Cluj-Napoca and Eforie) with maximum AOD observed on August 1 (Fig. 4c,d) also occurred in the lowermost 1.5 km layer, originating from the southeast of Ukraine and Moldova (also the area with active fires). Back trajectories for Moscow and Toravere with a maximum AOD on August 7 are shown in Fig. 4e,f, respectively. Aerosol to Moscow was transported mostly from

C18

the surrounding regions with the most active fires. Air masses over Toravere (Fig. 4f) originated from Asian regions and crossed areas of active fires in southeastern Ukraine in all analyzed altitudes (Fig.2g).

To Kyiv, where the AOD maximum was observed on August 15, aerosol was transported in the lower 4 km layer from the most active fires in the ETR, Ukraine, and Moldova (Fig. 4g, Fig. 2h). On August 16, the maximum was recorded in Sevastopol on the Black Sea coast, where air masses traveled in almost the entire range of analyzed heights (500 m–5 km) from the ETR and Kazakhstan through the territory of active fires in the south-west of Russia (Fig. 4h). In Minsk and Bucharest the maximum AOD was observed one day later on August 17 (Table 1, Fig. 4i,j). Towards Minsk aerosol was transported at 3 km from Kazakhstan across the Caspian Sea, southern Russia, and Ukraine, where the active fires were observed; at 1.5 km from Ukraine, and at 500 m from the western regions of the ETR through Ukraine. To Bucharest aerosol from fires was transported at 500 m from the north-east, specifically through the ETR and the south-east of Ukraine.

According to the monthly weather reports of the Ukrainian Weather Center, a change in weather was observed on August 18-21. Atmospheric fronts of an active cyclone which moved from the southern Baltic region to Samara led to a significant change of weather pattern in Eastern Europe. This change caused a distinct decrease in fire activities and a wet deposition of aerosol, lowering its content in the atmosphere above all investigated regions in the second half of August.'

Figure 3: Use of different dates does not help the understanding of the atmospheric circulation over the area in the investigated period. I suggest including a figure with wind patterns over the whole region at the different levels and dates, to be coupled to fires info of Figure 1.

We thank the Referee for having drew our attention to this issue. The aim of Fig. 3 (in reworked version of manuscript it is Fig.4) was to show that the maximum AOD values in the different AERONET stations were formed under conditions of transport of air masses from the areas of active wildfires. We did not include the map with the winds at the different levels and dates as we are sure, that HYSPLIT model correctly represents the transport of air parcels. We achieved such conclusion after comparing HYSPLIT back trajectories with weather charts (not included in this paper) near the surface - 1000 hPa, at 1.5 km - 850 hPa, 3 km - 700 hPa, and 5 km - 500 hPa, provided by Ukrainian Weather Service, and also accessible at http://www.wetterzentrale.de/ and http://www.wetter3.de. Moreover, to our opinion, the coupling of wind maps into Fig.1 (now Fig.2) would not be possible as it accumulates fire pixels over the 10 day period (not the average number of fire pixels).

As a further suggestion, it would be more useful to plot back-trajectories together with the fires data to better understand if and how each site was (possibly) impacted by fires.

We thank the Referee for his/her suggestion. To further avoid additional Figures in the manuscript and save the space, we have added the location of the AERONET sites to Fig. 2 in the reworked paper. Please, see Fig.2 above or on P10 of the reworked manuscript. We believe that this Figure addresses well location of the AERONET sites and spatial distribution of fires, accumulated over the 10 day period during summer 2010.

Section 3.2

Section 3.2 is too long and confusing. It is not clear how much new information it contains with respect to Milinevsky et al. (2014). To my opinion, the authors should

avoid describing what happens each couple of days and limit the analysis/discussion to the most important periods identified (e.g. those identified in Section 3.3), stressing on the results quantifying the fires impact over Ukraine in summer 2010 (as promised in the title). In doing so, it is important to clarify what was already known based on previous literature, and which are the new findings of this work.

We agree with the Referee and we have reworked this Section. We have revised the beginning of the section on P12 L10-18 as follows:

'Between 2003 and 2014 ground-based and satellite observations showed the highest aerosol content over Kyiv every year in spring (April–May) and late summer (July–August; Bovchaliuk et al., 2013; Milinevsky et al., 2014). According to both studies, the observed spring peak in aerosol content is associated with transport of the Saharan dust across Eastern Europe, transport of sea salt aerosol from the Black Sea and the Sea of Azov, and occasionally occurring agricultural fires. The summer peak results from wildfires, soil dust aerosol due to harvesting activity, and transport of Saharan dust. The lowest AOD was observed in June and the middle of autumn. In Table 2 we show a prolongation of the data record of Milinevsky et al. (2014, 2008-2013) for the Kyiv AERONET site by three more years up to the end of 2016. Even in this extended record the most significant aerosol pollution was observed in August 2010. This event is related, in particular to wildfires in the ETR and Eastern Europe'.

We have reworked Table 2 (reworked manuscript P14) and recalculated AOD values for 500 nm to be consistent in our study. We do not use, show, or refer to AOD 440 nm in this manuscript any more. We also have extended Table 2 up to 2016 (all available level 2.0 data for the Kyiv AERONET site). Thank you.

C21

We have also moved the description of air transport each couple days within June-August 2010 to the Supplement.

Figure 4b is redundant

We have removed Fig. 4b. Thank you.

Figure 5 should be removed or inserted as supplementary.

We moved Figure 5 to the Supplement. Thank you.

Page 16 Line 7-9. This last part of the Section is perhaps the most interesting one, in the sense that it adds information with respect to previous studies. However, these sentences should be rewritten to be more clear. For example avoid saying 'The fires impact on aerosol size from AERONET observations can be estimated by knowing XXX and size distribution of the aerosol particles XXX', as this is quite obvious. Again, the authors should try to focus on the most interesting results, without unneeded redundancy.

We agree to the Referee and revised the sentence on P15 L18-19 as follows: 'We estimated the impact of fires on the aerosol size from AERONET sunphotometer observations by calculating correlation coefficients between the aerosol effective radius and AOD (Fig. 6a), following the approach of Chubarova et al. (2012)'.
We have also revised the paragraphs on P15 L19-P16 L5

Figure6c: How do you explain the low values of SSA all over the spectrum in Jul18-Aug

C22

14 with respect to Aug 15-17?

The decrease of SSA during July 18-August 14 most probably was caused by increase of soot content in the air, which was transported from the fires. And increased absorption of aerosol in the long-wave part of spectra is explained by the slope of SSA curve, which becomes steeper. Similar shape of the SSA curve is also observed during August 15-17, which agrees with increased absorption of aerosol and is similar to the period July 18-August 14. But larger SSA values during this 3 day period can be explained by increased size of particles, which caused an increase of atmospheric column reflectance. We have addressed this issue on P15 L35-P16 L1 as follows: 'According to Eck et al. (2009), larger SSA values can be explained by an increased particle size which increases the total reflectance of atmospheric column'.

Table 3. As already commented, SSA is not a microphysical property. Please, reduce the number of significant digits. I also recommend moving it to the supplementary, as it does not add much to results in Fig. 6.

We have moved Table 3 to the Supplement(Table S35, P12), changed the caption of the table, reduced the number of significant digits. Thank you.

Section 3.3

Page 17 Line 5. Again, caution using the term FRP as this was not introduced/shown in Section 2.

We agree with the Referee's comment and have avoided the application of term 'FRP'.

C23

Thank you.

Page 17 Lines 7-8. Unclear, please rephrase.

We have removed this paragraph as we do not divide summer 2010 in this Section into 3 periods in the reworked version of manuscript.

Section 3.3.1

This section is largely a description of the methodology to match AERONET and MODIS data. Page 19, Lines 3-25) could be better moved in a specific section within the Methods.

We agree with the Referee and we have moved the description of methodology into Section 2.2. Please, see P6 L23-30.

Figure 7 : I would use a different scale for the two panels. In the present form panel a) gives little information.

This is a good point. We agree that with the current scale Fig. 7a shows only relatively low AOD values over Ukrainian territory on July 17, which are homogeneously distributed. Fig.7a becomes more interesting in combination and comparison with Fig. 7b, which represent AOD values in August 15. Such a combination shows the major AOD increase in August within the whole summer 2010.

Page 21 Lines 9-17. Language should be improved.

C24

We have improved the wording of this paragraph on P17 L16-29 as follows:
'The influence of aerosol pollution in Ukraine can be interpreted from the spatial distribution of MODIS AOD 550 nm. We analyzed data for 7 days with low AOD values, smaller than 0.5 over the Kyiv site: June 6 and 7 (MODIS/Terra), June 8 (MODIS/Aqua); July 14 and 17 (MODIS/Aqua), July 15 (MODIS/Terra); August 23 (MODIS/Terra). We also analyzed 3 days (August 15–17) with high AOD values, larger than 1.0. Figure 7 shows maps for the region 40-60N and 22.5-40E of MODIS/Aqua data for those two days when the aerosol load over the Kyiv AERONET site was low (a, July 17) and the highest (b, August 15). During the days with low aerosol content the AOD 550 nm was homogeneously distributed (e.g., Fig. 7a) over the whole territory. During the high pollution case, the spatial AOD distribution distinctly differed. The highest AODs were observed over north-eastern and central regions of Ukraine, where AOD values reached and partly exceeded a value of 2 (Fig. 7b). This AOD distribution map (Fig. 7b) resembles our air mass back trajectory calculations to Kyiv in the altitude range of 0.5–3 km for August 15 fairly well (see Fig. 3, Sect 3.1). This indicates that the MODIS algorithm interprets aerosol over Kyiv in the same manner as AERONET. However, MODIS underestimates low AOD values and overestimates high AOD values in comparison with AERONET. Figure 7b also highlights the importance of the availability of satellite observations for estimating air pollution over larger and remote regions, which cannot be deduced from a single site's ground-based measurements, as it is the case in Ukraine'. Thank you.

Section 3.3.2

Similarly to the previous case, this section is largely a description of methodology rather than of results. Please, try to separate methodology from results as this would help a lot the reading of the work. This section shows the same problem of others, i.e.,

C25

it is structured as a list of dates with description of features, but lacks a synthesis of the main findings CALIPSO data tell us about the phenomenon under examination. It should be shortened and restructured so to highlight which is the important (possible quantitative) information CALIPSO adds to the overall picture.

We agree to the Referee and reworked the Section 3.3.2 .We have moved the description of the methodology to the Sect. 2.3. Please, see P7 L23 - P8 L12.

Page 22 Line 5. Specify where (in altitude) the laser beam has a 70 m diameter. Due to the beam divergence, this is not the same all over the laser path.

We moved this sentence to Section 2.3 and specified that the footprint of the laser beam is 70 m on the Earth's surface as follows: 'This results in the footprint on the Earth's surface, called in our paper ground track, of about 70 meters'. Please, see P7 L16-17.

Page 22 Line 10. What do you mean by 'estimated CALIPSO AOD using MODIS AOD'? Please clarify better.

We have corrected the sentence as follows: 'Therefore, in this study we only compared CALIPSO/CALIOP CloudAerosol Layer Product AOD 532 nm (Winker et al., 2009, 2010) with MODIS/Aqua AOD 550 nm since the orbits of both satellites are in the A-Train afternoon constellation (http://atrain.nasa.gov/)' and moved the sentence to Section 2.3, P7 L32-34.

I do not see the reason for introducing the further term 'time-span' in this Section.

C26

Please identify specific periods of interest for the study, give them names, and use these all through the text.

We agree with the Referee and have completely removed the term 'time span' together with Table 6 and Table 7.

Page 24 Lines 16-17. What do you mean by 'ground track'? Please specify.

We refer to the term 'ground track' to define the footprint of CALIOP lidar measurements on the Earth's surface. We have provided the explanation on P7 L14-17 as follows: 'The laser beam is directed almost at nadir with a slight forward tilt in the direction of motion of the satellite to avoid direct reflection of laser radiation from high reflectivity objects (surface water, snow, etc.). The divergence of the transmitted laser beam equals 100 μrad. This results in the footprint on the Earth's surface, called in our paper ground track, of about 70 meters'.

Page 22 Lines 17-19. Unclear, please rephrase.

We have addressed this issue in Section 2.3, P8 L3-5 as follows: 'Each of these points represent the center of the CALIOP measurement averaged over 5 km which matches with one of the pixels of a MODIS granule'.

Figure 9. Please group profiles according to the three types you identify in the text. It is necessary to include labels a) to g) on a map (e.g. in Figure 8) to show the relevant location and better follow all the discussion in the text. Use the same X and Y- scale for all plots to simplify the comparison.

C27

We agree to the Referee's suggestions and have provided several improvements:

- We have introduced one more aerosol profile For August 18 on Fig. 9 and substituted profile 'b'

- All profiles were set in chronological order

- We have included the term 'type of profile' to each (a-h) profile, shown in Fig. 9

- We have reworked the caption of Fig. 9 as follows: 'Selected vertical profiles of aerosol extinction coefficient from CALIOP measurements over Ukraine during active fires period in summer 2010. The location of profiles is shown in Fig. 8b with corresponding a-h labels'

- We have included the location of these profiles on Figure 8b with a-h labels.

Please, see reworked Figures 8 and 9 below and/or in the reworked manuscript P18, P19 correspondingly.

Why not using the CALIPSO depolarization to further characterize aerosol layers?

We agree with the Referee that the application of CALIPSO depolarization data would provide us additional information on aerosol properties, size, and shape. In our research we applied AERONET ground-based measurements to further analyze aerosol

C28

spectral SSA and microphysical properties with the focus on the Kyiv site. The application of additional data set would at the first place extend the size of the paper, which we try to avoid. We also believe that this research should be performed additionally and published as kind of extension of our study with incorporating data from other years since 2010.

Section 4

Page 27 Lines 6-17. I would avoid the discussion on the reason for CALIPSO and MODIS AOD mismatch here. It is not very pertinent to this study and in the present form contains several questionable statements. In general, this section is also too long (3.5 pages). It has to be shortened once all the given suggestions have been addressed. It would be desirable to restructure this section in order to have a sort of 'main finding list' here.

We agree to the Referee and we have entirely reworked this Section. Now it better highlights our findings, because we have avoided detailed comparison of our results with other authors as it was done in the previous version of the manuscript. Please, see the rewritten version of Conclusions on P22 L4-P23 L32.

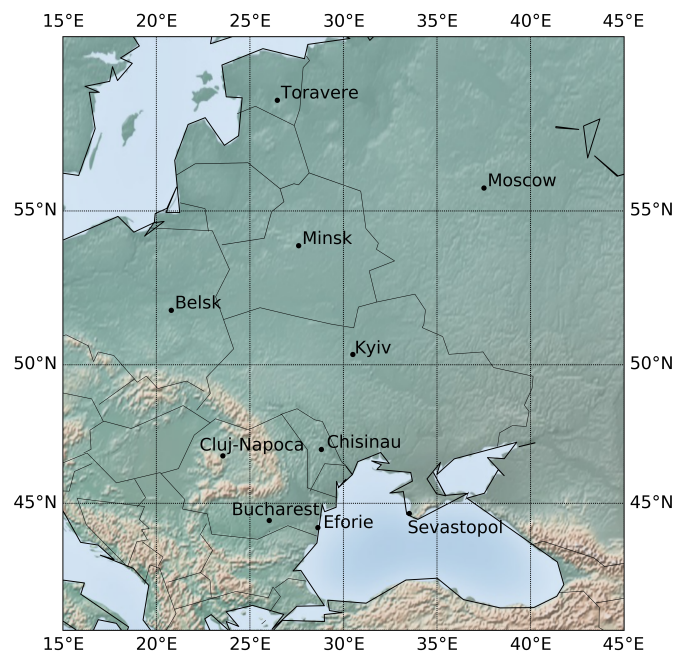Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2017-336, 2017.

C29

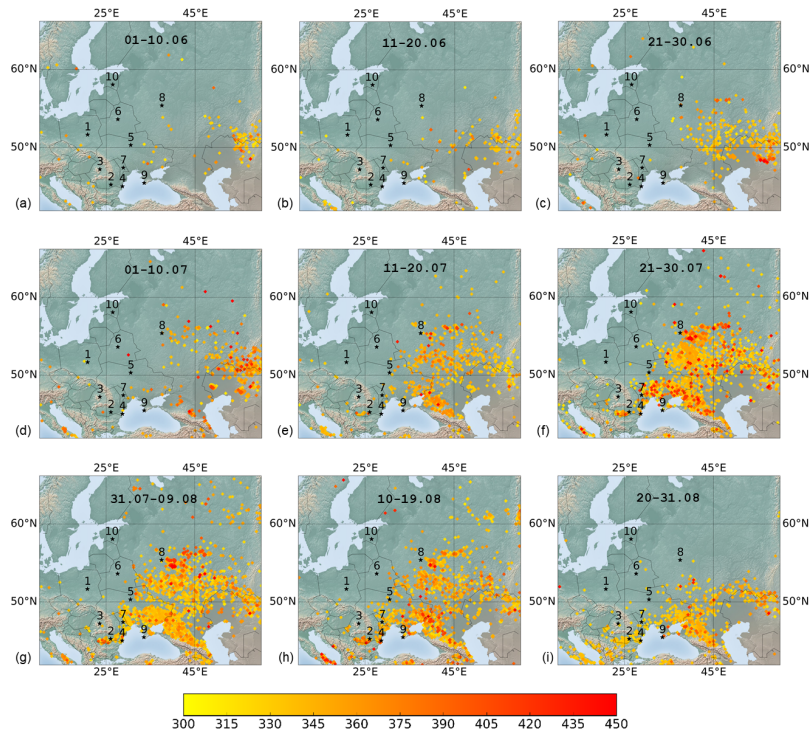**Fig. 1.** AERONET observational sites in Eastern Europe and Ukraine used in this study.

C30

Fig. 2. Fire locations and brightness temperature (in K) of fire pixels in the ETR and Eastern Europe (40–65\degree N and 10–60\degree E) detected by MODIS and accumulated over 10 day periods.

C31

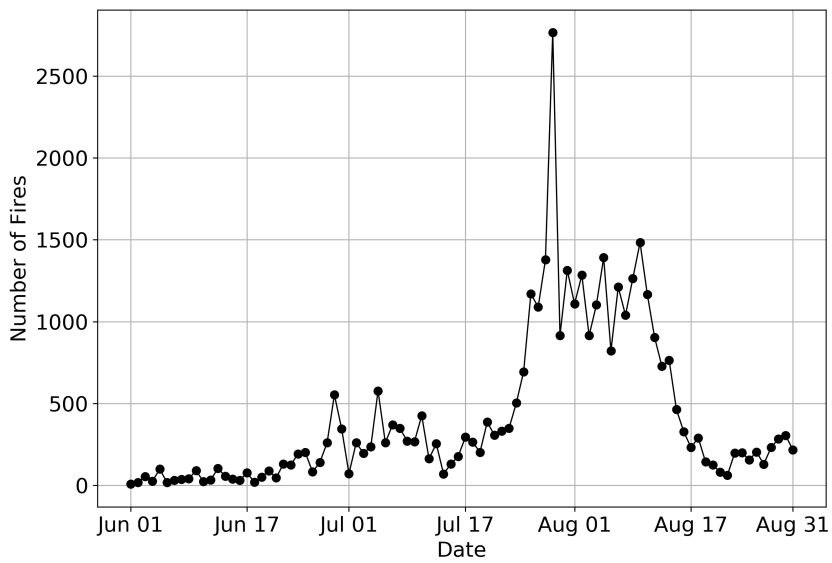**Fig. 3.** Total amount of fire pixels for each day of summer 2010 according to MODIS Aqua and Terra data over the area shown in Fig.1 (40–65\degree N and 10–60\degree E).
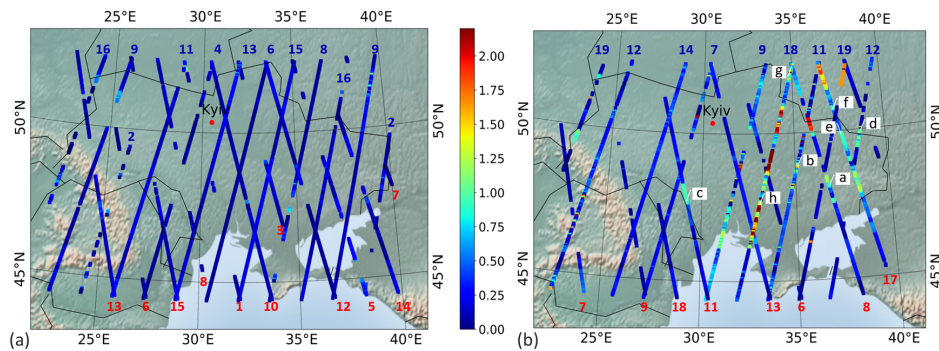
C32

Fig. 4. AOD 532 nm distribution over Ukraine from CALIOP measurements during 16 day period from June 1 to 16 (a), from August 4 to 19 (b), 2010.
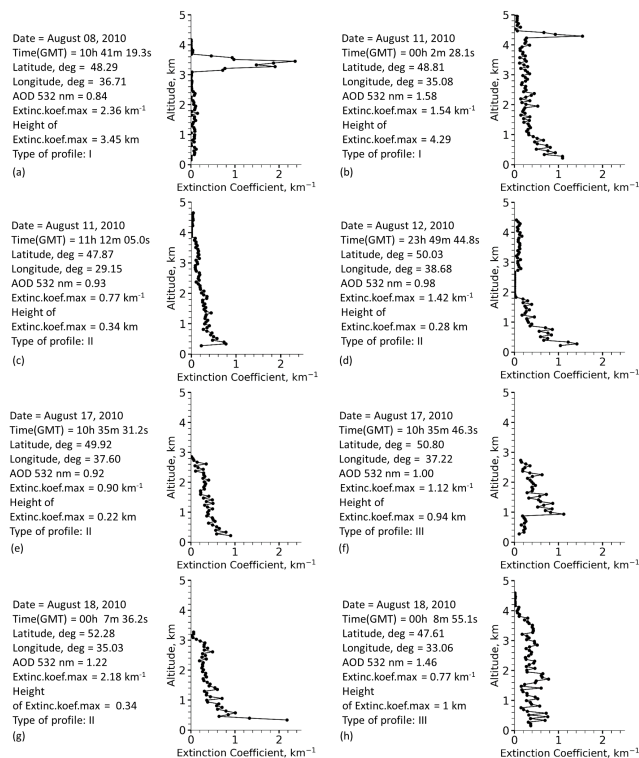
Fig. 5. Selected vertical profiles of aerosol extinction coefficient from CALIOP measurements over Ukraine during active fires period in summer 2010.