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

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egalytska@iup.physik.uni-bremen.de

We thank the Referee #4 for the time he/she spent on reading and revising the manuscript and raising a number of important points. We are following the Referee's suggestion and reworked the manuscript. Below we address all raised points one by one. All authors' responses are highlighted in blue. We address notation as follows: P1 L12 means page 1, line 12.

Review of Increased aerosols content in the atmosphere over Ukraine during summer 2010, Evgenia Galytska, Vassyl Danylevsky, René Hommel, and John P. Burrows.

This study re-visits the fires of summer 2010 over western Russia and surrounding countries. The impact of aerosol burden and composition over Ukraine are evaluated. This study closes the loop on analyses using aerosol data from satellite and in-situ measurements to discuss that effect of the Russian fires on neighboring countries; specifically in this case, Ukraine.

The study is poorly written. There are numerous* issues with the grammar and sentence structure (I've included a few of the most egregious ones) that I strongly suggest having a colleague (fluent in English) vet the sentences for clarity and syntax. In particular what is missing is 'the' for proper nouns. For example in the text authors say 'we used data mostly from Kyiv site' when it should be written 'we used data from the Kyiv site'. Authors also pluralize words that should be singular.

Furthermore, authors do not stay on one tense. Pick one: past or present. The manuscript requires a re-read on this. Such error is too extensive to document.

We agree to the Referee #4 and we improved the grammar of the manuscript. We carefully 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.

Having said that, the method and general results are not faulty. Ignoring the poor English, the study is good enough to be publish with major revisions, such as improving the writing and additional analysis to support many of the authors claims.

We appreciate very much the comment and we have reworked and reorganized the manuscript to highlight its novelty, reduced its length by restructuring methodological

paragraphs. In particular, we have introduced the following changes:

- We have shortened the Abstract

- All acronyms have been spelled out the first time used

- We have rewritten the Introduction and inserted in Sect. 2 a figure showing a map with AERONET observational sites in Eastern Europe and Ukraine, which were used in our study (Fig.1 in the reworked manuscript)

- We have optimised the titles of Section 2 and 3 to better address the sections subject.
  In detail, Section 2 has been renamed from "Data sources " to "Methods and data sources". We aim to collect there all relevant information about methods used in our study. In the original manuscript, respective information was partly spread over the different sections describing results of our study. The current form of Section 2 allows the reader to better understand the core messages of our analysis and conclusions - statements that are now not interrupted by technical information.
  Section 2.4 has been renamed from "Meteorological data and the means of study of air masses transport in the investigated region" to "Weather conditions and transport of air masses", now even more precisely state the purpose of the information provided there.
  In this respect, Section 3 has been renamed from "Methodology and results" to "Results and Discussion". Majority of Figures, Tables and their captions have also been reworked and improved (please, see the updated version of the manuscript).

- We have shortened Sections 3 and 4 by generally more focussing on our major findings and their interpretations.

Authors write 'summer' 2010 in the introduction - define the months or was it one month, i.e. August, which you quote from previous studies? Be precise is it summer or merely August?

We make this point in re-written Abstract (P1 L2) and in Introduction (P2 L7), where we have defined the months in parenthesis, e.g. (June 1-August 31).

3rd paragraph in abstract - Remove 'apparently'. High pollution over Moscow that summer 'was' due to the fires. There's nothing apparent about it.

Thank you. We have rephrased the sentence and removed 'apparently' (P1 L9-10).

- I do not like the term 'combustion center'. Be precise – it was fires.

We have corrected 'combustion centers' to 'fires' all over the manuscript. Thank you.

- 'aerosol content' - singular.

We have replaced plural 'aerosols' with singular 'aerosol' all over the manuscript. Thank you.

Last sentence in abstract: 'change of the particle microphysics'

We have corrected the sentence to "change of the particle microphysics" (P1 L22). Thank you.

Pg 2, Line 4: but a 'non' negligible

We have added the reference of Barnaba et al., 2011 to the particular sentence and retained the original usage of word "not".

Last sentence of the Introduction first paragraph needs to be re-written. The sentence is long for one.

Thank you. We have rewritten the sentence as follows "For several years great effort has been devoted to the study of the spatio-temporal distribution of aerosol in summer 2010 over the ETR and Eastern Europe." and now it is on P2 L13-14.

Pg 2, Line 33: Remove indentation. Join paragraph to previous one or give the Konovalov et al study it's own paragraph.

We gave Konovalov et al. (2011) it's own paragraph, moreover, we analyzed all previous studies in chronological order.

Also, you define AERONET here but have already used it in the second paragraph.

Thank you. AERONET and other acronyms have been spelled out the first time used.

Define ETR

ETR and other acronyms have been spelled out the first time used.

Pg 3 line 6: 'aerosol'

Thank you. Change made.

Pg 3, line 10: Elaborate on the 'synoptic situation' – I assume this is meteorology driven definition.

Thank you for raising this issue. We replaced 'synoptic situation' with 'weather conditions' all over the manuscript.

Pg 3, line 34: 'in-detail studies' – poor English.

The text has been changed to 'Our research contributes significantly to the above mentioned studies of Bovchaliuk et al. (2013) and Milinevsky et al. (2014), but unlike them, we focused on a comprehensive evaluation of the impact of the fires in summer 2010 on the tropospheric aerosol load with a major focus on Ukraine' and is now in P4 L1-3.

Pg 4, line 1: 'meteorological situation' – poor English - informal.

We have reworked the sentence and replaced 'meteorological situation' with 'weather conditions'. Updated sentence looks as follows: 'We reproduced the weather conditions with the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model'. P4 L4-5

The Introduction needs work:
Authors need to do a better job expanding the first paragraph emphasizing the impact of Russian wildfires and making that distinction between fires and wildfires. Authors need to review and answer:
- What made the Russian 2010 fires exceptional? - How did it start? - How did it evolve? - Why is it important to study? (don't just state it and who is this international scientific community?) - Justify why after seven years, another study of the Russian wildfires is necessary?

We completely agree and support the suggestion of Referee. We have reworked the Introduction entirely.
At the beginning rewritten Introduction addresses the importance of wildfires as a global source of aerosol.

Then we provide the description of importance of wildfires events during summer 2010. The second paragraph explains the main reasons of occurrence of fires (extreme heatwave on summer 2010, e.g. Barriopedro et al.,2011; Schevchenko et al., 2014) caused by high temperatures and low relative humidity, e.g. Witte et.al, 2011.

Later, we address to previous studies (in chronological order) devoted to aerosol dynamics over the European territory of Russia (ETR) and Eastern Europe. We have also highlighted the papers of aerosol research performed for the territory of Ukraine.
At last, we have explained the contribution and novelty of our research in comparison with other works, its driving motivation and significance/necessity. We have completely withdrawn the usage of term 'scientific community'.
We have made suggested changes on P2 L2-P4 L11

More in-depth review of the Russian fires is required because at this point I don't know what notable contribution this study makes or why it is important to continue studying

this one-time event.

We have addressed this issue in the second paragraph of the Introduction as follows: 'Extensive wildfires during summer (June 1-August 31) 2010 over the European Territory of Russia (ETR) and partly Eastern Europe were caused by an extreme heatwave, that led to an all-time maximum temperature record over numerous locations (Barriopedro et al., 2011; Dole et al., 2011; Demirtas, 2017), including the territory of Ukraine (Shevchenko et al., 2014). High surface temperatures (35-41C) and low relative humidity (9-28 %) over those regions (Witte et al., 2011) favored the occurrence and persistence of fires. In turn, those fires caused significant air pollution in populated areas of Russia and combustion products (gases and aerosol) were spread over large areas of Eastern Europe.'

Although it is very worthwhile to review the seminal papers that covered the Russian wildfire the authors do not go about it sequentially. Review each study separately – give them their own paragraph if necessary, tie them together by theme (satellite, model and in-situ or aerosol parameter or other), then introduce your study.

We followed the suggestion of Referee and reviewed each study sequentially and separately. Gave for each study its own paragraph.

Twice authors have introduced their study in different parts of the introduction.

We have removed repeating text and introduced the contribution and novelty of our research in the last paragraph of the Introduction. Please, see rewritten version of Introduction on P2 L2-P4 L11 in the reworked version of the manuscript.

Pg 4, lines 12-14: metrology is a noun, not a verb. That entire sentence needs to be revised.

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

Pg 4, line 20: missing parenthesis in Holben et al

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

Pg 4, line 23: you mean inversion algorithm.

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

Section 2.1 - I would like to have a map of the sites listed in Table 1, in which you use data. Context is required.

Thank you, we have inserted the map with the AERONET observational sites in Eastern Europe and Ukraine, which were used in our study. Please, see below Fig. 1.

Pg 5, line 2 – This is a repeat sentence. Authors already mentioned using L2 data.

We have deleted the repetition, thank you.

Sentence in Pg 5, lines 10-13 needs to be re-written.

We agree with the Referee and have rewritten 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

Pg 5, line 15: We 'use' – stay on one tense.

We thank the Referee for highlighting this issue. We kept 'we used' as we have corrected the manuscript with the Past tense.

Pg 5, lines 17: what are the 'favorable weather conditions' ?

We have completely withdrawn this sentence. Thank you.

The title of section 2.4 is poorly written. It needs to be re-written

We agree with the Referee and have corrected the title to "Weather conditions and transport of air masses'. Thank you. P8 L13

Section 2.4 is the first time you mention the time period of your study. This needs to

be mentioned in the introduction when you introduce your study.

We thank the Referee for this comment. We have added the time period (June 1-August 31, 2010) to the Abstract and Introduction.

Again, the English needs to be cleaned up in Section 3.

We agree with the Referee and improved the grammar and syntax in Section 3.

The following sentences are poorly written: "Significantly higher chance of AERONET site to be into the MODIS field of view and it provides opportunities for both instruments data comparison. In the following, first we directly compare MODIS AOD to sunphotometer AOD, followed by comparing the AOD of CALIOP to MODIS."

We have reworked Section 3 and moved description of methodology to corresponding subsections of Section 2. The sentences, mentioned by the Referee have been withdraw completely. Description of MODIS-AERONET comparison procedure is provided in Sect. 2.2 on P6 L23-30. Description of CALIOP-MODIS comparison procedure is provided in Sect. 2.3 on P7 L32-P8 L12.

Section 3: In the first paragraph you write 'We assess the influence of biomass burning during summer 2010 on aerosols over Ukraine and neighboring territories . . .' then in the last paragraph you again write 'To identify the impact of fires on air pollution by aerosols over Ukraine, including Kyiv . . .' . These two sound the same and repetitious.

We agree with the Referee that these repetitions are inappropriate and have withdrawn

them completely. In the reworked version of manuscript the methodology is provided in Section 2.

The title of Section 3.1 is not precise. The Russian fires were a combination of forest, grass, and peat burning, as you previously mention. The title should either remove 'forest' or be precise and be 'forest, grass, and peat fires'.

We have made the change in title of Section 3.1 as follows 'Impact of wildfires and weather conditions during summer 2010 on aerosol air pollution in Eastern Europe'. Please, see P9 L1.

Again what is ETR?

The ETR has been spelled out the first time used. Thank you.

Again, I want to see a map of the locations of all cities in Table 1.

Thank you for the suggestion. We have inserted the map with the AERONET observational sites in Eastern Europe and Ukraine, which were used in our study. Please, see Fig.1 on P5.

Section 3.1: You refer to this 'synoptic process'. What is it? You mention meteorology quite a bit without actually explaining the weather conditions that set-up the ideal conditions for the wildfire to rage across the Eastern Europe.

Thank you for raising this issue. We replaced 'synoptic situation', 'synoptic process' etc.

with 'weather conditions' all over the manuscript.

In this section I would like authors to actually write about the meteorology instead of referring it in vague terms such as 'synoptic situation' (i.e. look at temperature, winds, pressure, RH or remove meteorology from the section since you don't talk about it).

That is the interesting idea. However, anomalies of surface T and RH for the territory of Western Russia (in our manuscript is the ETR) were shown by Witte et al., 2011. Moreover, Shevchenko et al., 2013 used maximum air T for 13 Ukrainian stations including summer 2010 to analyze heat waves events, which are defined as episodes with extremely high air temperature with duration of several days. That is why we have removed meteorology from the section and analyzed trajectories of air transport only.

Section 3.1 Last paragraph: Where do you see this change in synoptic processes on Aug 18-21?? You do not show a front or any changes in weather patterns. Are you quoting another study? These are grand conclusions without any data and results to back it up.

We agree that we have not been precise enough and we have improved the text as follows: 'According to the 5 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'. P12 L5-8

Although, monthly weather reports of Ukrainian Weather Center are available only

in Ukrainian and only after special request. Such a rapid change of weather is also seen in HYSPLIT back trajectories, calculated for the Kyiv site. We have added these trajectories and their description to the Supplement, Fig. S32-S34.

Table 1: What is the actual time period over which you calculate these values?

We have improved the caption of Table 1 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)'.

Pg 9, line 2: The word 'apparently' should be removed. Many studies have already proven the fires caused the high air pollution over Moscow – there's nothing apparent about it. Also replace 'combustion center' with what it actually is – fires. This term is not precise and can denote alternative combustion sources, such as anthropogenic.

We have removed 'apparently' and replaced 'combustion centers' with 'fires'. Thank you.

Pg 10, Back-trajectories show anti-cyclonic tendencies at most sites, other than Moscow and Toravere. The authors fail to notice the temporal and special extent of the stagnant anticyclone over Eastern Europe in their trajectory analysis.

We agree with the Referee and have addressed this issue on P9 L24-27 as follows: 'Our analysis of back trajectories revealed that air movements in the lower 5 km layer of the troposphere corresponded to anticyclonic circulation, which is seen in Fig. 4a-j at various altitudes as clockwise-shaped curves. The maximum AOD values from ten AERONET sites in the ETR and Eastern Europe were formed under conditions of air stagnation and accumulation of contaminants'.

The analysis in Section 3.1 is missing a large chuck of key information. I don't understand how the authors determine the height of the maximum AOD! Up to now, analysis has not been done to show where the peak in the aerosol profile is located to justify picking those heights. How do the authors determine these heights?

We thank for having drew our attention on this and agree that the reasoning was not precise enough. We make this point on P8 L24-25 as follows: 'We chose the lowermost 5 km tropospheric altitudes taking into account the analysis of the vertical distribution of aerosol according to CALIOP data (shown in Sect. 3.3.2).'

There are many places where it is written 'aerosols' when it should be singular. Double check.

Corrected to 'aerosol' all over the manuscript. Thank you.

Section 3.2
Pg 10, line 28: what is the 'period of observation'?

We have reworded the sentence as follows: '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'. P12 L15-16

Table 2: Now you are using a different AOD (440 nm) whereas before you were using 500 nm. What is the difference between using two different wavelengths? I think that needs to be explained. Are you using this wavelength to match with the Milinevsky et al study?

We have reworked the Table 2 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.

Pg 11: Authors keep changing the description of the fires. Here is written 'active fires of vegetation'. Is it wildfires, forest fires, vegetation fires, combustion center, or fires of vegetation? Stick with one descriptor and be consistent. This is not an exercise in creative writing.

Thank you for the comment. We have corrected this issue and used 'wildfires' term throughout the entire manuscript.

Figure 12: Year is missing. Specific dates are mentioned in the text and it is hard to see on the x-axis. I would like authors to mark these dates referred to in the text.

We believe, Referee ment Fig. 4 on p.12. In the reworked version of manuscript this is Fig. 5. We have updated the capture of the Figure as follows: 'AOD 500 nm over

Moscow and Kyiv (a), AE over Kyiv (b) during June 1-August 31, 2010'. We have also removed Fig. 5b as it was redundant. Thank you.

Pg 12, line 1: Use 'pronounced' rather than 'distinctive over Moscow', which was written incorrectly to begin with.

Corrected to 'pronounced'. P12 L19. Thank you.

Also, the next sentence needs to be re-written.

We have rephrased the sentence as follows: 'However, the aerosol pollution over Kyiv was also exceptional in comparison with the multi-annual average'. P12 L20.

Pg 13, sentence in lines 5-6: Are you referring only to June 1-2? Why bother? mid-June and the end of June show, by far, the lowest AE. You also show almost 40 observations for June 1 in Figure 5, so I don't know what authors are alluding to here.

We agree with the Referee's comment and we have moved the description of air transport each couple days within June-August 2010 to the Supplement. We believe that the precise analysis of transport of air masses within June -August 2010 is important, thus have not withdrawn it completely. By moving this piece of text to the Supplement we reduced the size of the manuscript but still kept the information available. We address to this issue on P12 L26-27 as follows: 'We provided detailed description of AOD variations and the impact of air transport on those changes in the Supplement Fig. S1–S34'. We also have moved Fig. 5 to the Supplement.

Pg 13, first sentence in line 9: 'unstable weather, sometimes with clouds' – where are you getting this information? The language is also informal. For this paragraph what figures are you referring to that you're generating this analysis?? I shouldn't have to guess. I would like to see a graph of cloudiness and a precipitation index superimposed on the Figure 4c. The authors make numerous inferences to cloudiness with no supporting data.

We agree to the Referee that referring to clouds requires adding of supporting plots/data. Although, as we mentioned above, precise analysis of transport of air masses has been moved to the Supplement. As long as we do not mentioned these cloudy weather conditions in the reworked manuscript, we believe it is not necessary to add supporting data any more. Thank you.

Pg 14, line 3: Which figure are you getting the AOD at 500 nm value? What is the significance of switching between AOD's?

We have moved this analysis of transport of air masses to the Supplements. Also, we switched our analysis to AOD 500 nm completely. In the reworked manuscript Fig. 5a represents AOD 500 nm time-series over Kyiv and Moscow.

In Section 3.2 – specific dates are being analyzed. I would like to (1) know which figures are being referred to and (2) a figure with the AOD (440 and 500) and the specific dates referred to in this section. Alternatively, a table will also work. This section is not easy to follow, particularly since the bulk of the analysis is located in the supplementary. Summarizing all this as a table should help.

We thank the Referee for his suggestion. We have moved the analysis of air transport

during June-August 2010 to the Supplement. We have also switched our analysis of AOD to the wavelength of 500 nm and do not mix with 440 nm anymore.

Pg 14, sentence line 18-19: 'As seen from Fig 1a . . .' this sentence is imprecise and informal.

Thank you. We have moved this text to the Supplement and have corrected the sentence there as follows: "Fig. 1a shows that..."

Pg 14, line 33: '. . .different types of fires . . .'. How do you know that?

We have moved this sentence to the Supplement and have substituted 'different types of fires' by fires'. Thank you.

Figure 6: you have the legend reversed: fine mode is the top curve/course mode is the bottom curve.

We have corrected the capture of Figure 6. Thank you.

What are the '3 periods' ? Are they written in (b) and (c). I shouldn't have to guess.

We have changed the caption of Fig. 6 on P16 as follows: 'Aerosol spectral SSA and microphysical properties from AERONET measurements at the Kyiv site during summer 2010: (a) – particle effective radius versus AOD for fine (left axis, top curves) and coarse (right axis, bottom curves) modes averaged for the entire summer 2010; (b) – particle size distribution, (c) – spectral SSA, (d) – spectral RI, – real (right axis,

top curves) and imaginary (left axis, bottom curves) parts. Representative periods are June 1-26 (triangles down), July 18-August 14 (triangles up), August 15-17 (circles), and August 18-31 (squares)'. Thank you.

Section 3.3

I would like to see a time series of AOD 500 and the periods of the pre-, active-, and post- fires that authors define.

Figure 5a provides AOD 500 nm time-series for the Moscow and Kyiv sites for the period June 1-August 31, 2010. We have decided to avoid the division of summer 2010 into pre-, active-, and post fires periods in order to simplify the understanding of the achieved results. Thank you.

How are these three fire periods different from Witte et al? Is there a time lag? How well-correlated is the onset, duration, and die-down of the fires over Russia compared to over Kyiv?

As we have mentioned in the comment above, we have avoided the division of summer 2010 into pre-, active-, and post- fires periods in order to simplify the understanding of our results.

Table 4: In the text you have resolutions of 10x10, 30x30, 50x50, however in the Table you have 10x10, 20x20, 30x30.

We thank the Referee for having drew our attention to this issue. In the reworked

version of manuscript we have completely withdrawn Table 4 and avoided the analysis for different resolutions in order to simplify the understanding of the results.

I assume AODSph means the sub photometer – that should be clearly stated in the table and text.

We thank the Referee for having drew our attention on this. We have spelled out acronyms MODIS/Aqua AOD (AOD_{myd}), MODIS/Terra AOD (AOD_{mod}), and AERONET sunphotometer data (AOD$_{Sph}$) the first time used.

Table 7. Replace 'Time span X' in the first column with the actual time period.

We have completely withdrawn Tabe 7. Thank you.

Section 3.3.2

Pg 24, line 3-4: AOD > 0.5 are spotty – are they near urban areas? Is this due entirely to fires or a mix with urban signatures?

We thank the Referee for raising this issue. We have reworked Fig. 8. We have included CALIOP measurements during June 1-16 (Fig. 8a), when almost no fires burned as seen from Fig. 2a, b; and during August 4-19 (Fig. 8b), when the ETR and south-east of Ukraine were occupied by fires (Fig 2 g,h). In Fig. 8b we have also shown the location of aerosol profiles from Fig. 9.
Figure 8a represents AOD spatio-temporal distribution in June 1-16, which was varying within 0-0.7. (Please, note that we have corrected from 0.5 to 0.7 in the reworked

version of the manuscript). It resolves possible impact of local sources such as city transport, heavy industry, etc. Figure 8b shows high AOD values in south-east of Ukraine. We assume that during August 4-19 aerosol was dominating from the wildfires. Thus, we believe that the increase of AOD represents the impact of both local sources and wildfires.

We have also shown in the reworked version of Supplement AOD 532 nm spatio-temporal variability from CALIOP in Fig. S36a-d: from June 17 to July 2 (a), from July 3 to 18 (b), from Jul 19 to August 3 (c), and during 12 day period from August 20 to 31 (d).

Pg 24, second paragraph: The June 1-July 18 CALIOP analysis – where are these data? I would like to see a similar Figure 8 but with this new period. Also, in this paragraph you say AOD is âĹij1 however, in the previous paragraph for the same time period you say AOD > 0.5. There are two competing thoughts here.

As we have mentioned in the previous comment, we have reworked Fig. 8. We have included CALIOP measurements during June 1-16 (Fig. 8a), and during August 4-19 (Fig. 8b). The remaining CALIOP measurements are now part of the Supplement (Fig. S36a-c) in order to save the space of the manuscript.

We have reworked the sentence on P19 L2-3 as follows: 'In particular, during August 9-18 AOD values regionally exceeded 1 and reached a value of 2 at certain locations'.

Pg 25, line 8: 'particle concentration' – this is not the only place where authors erroneously use the plural.

We agree with the Referee and we have corrected to 'particle concentration' on P19 L17-18

Pg 25, line 21: Where is the Lugansk region in figure 8?

We have avoided the usage of city names in the reworked analysis to simplify the understanding of our results and avoid any confusions. We have corrected the sentence as follows: 'CALIOP's nocturnal track on August 12 ran over the east of Ukraine, where the highest AOD 532 nm of about 1.0 was found (location labeled 'd' in Fig. 8b)'. P21 L13-14

Pg 26, line 15: It is an exaggeration to allude to territories when authors really only did an in-depth analysis over Ukraine.

We agree to the Referee and have completely withdrawn the sentence.

Pg 26, sentence line 30-31: '. . . CALIOP measurements was rather challenging task due to fragmentation of data and their high variability.' Fragmentation of data implies it's faulty – what exactly do you mean? Also, why would highly variable data be challenging. I think you mean simply is there isn't enough data comparable to AEROSOL and MODIS.

The Referee is completely right. We have withdrawn the entire sentence. Thank you for pointing this out.

In the discussion I would like to see a bullet form, or a concise summary list of the conclusions. I still don't know what they are or the value your study brings to this field. What are the key points of this study?

We have reworked this section with the main focus on our achievements. In the reworked section we highlight our main finding. Please, see rewritten version on P22 L4-P23 L32 and below:

'In this study we analyzed the influence of wildfires on aerosol dynamics over the ETR and Eastern Europe, in particular on air pollution conditions over Ukraine during an extreme heat wave event in summer 2010. Specific weather conditions with high air temperature and low relative humidity (Witte et al., 2011) formed under anticyclonic circulation, which caused air stagnation and accumulation of contaminants. Moreover, those weather conditions were favorable for wildfires to evolve.

To reveal the connection between wildfires and aerosol properties over the ETR and Eastern Europe, we analyzed fire locations and their brightness temperature from MODIS measurements for the period June 1-August 31, 2010. We demonstrated that the fire activities increased from mid-July mostly over the ETR, Ukraine, and Moldova. The largest number and brightness temperature of fires were observed during July 26-August 18. To consider the impact of those wildfires on aerosol dynamics over the ETR and Eastern Europe, we chose 10 AERONET sites in that region and computed HYSPLIT back trajectories to those sites. Our analysis of back trajectories showed that the observed AOD maximum over each of the considered sites was formed as a result of air transport from the areas of active wildfires. AOD maxima at the Belsk site (central Poland), Moldova (Chisinau, Moldova), and Cluj-Napoca and Eforie (Romania) were caused mainly by fires in Ukraine and Moldova in July. AOD maxima over other AERONET sites were caused by aerosol from fires in the ETR. We also provided detailed analysis of aerosol dynamics over Ukraine. Despite the available studies of

aerosol dynamics over Ukraine (Bovchaliuk et al., 2013; Danylevsky et al., 2011a, b; Milinevsky et al., 2014), we focused on the evaluation of the impact of the wildfires in summer 2010 on the tropospheric aerosol load, which has not been done before.

The ground-based AERONET measurements over the Kyiv site showed that for the entire observational period (from April 2008 to November 2016) the highest air pollution caused by aerosol was recorded in August 2010. The average AOD 500 nm in August 2010 exceeded multi-annual monthly mean (2008-2016, excluding 2010) by a factor of 2.2. We showed that during June 2010 the wildfires were not affecting AOD over the Kyiv site. Both, aerosol content and properties were determined mostly by local sources and air transport from Western Europe. In contrast, from July to mid-August, the AOD increase over the Kyiv site was caused by air transport from the wildfire regions. The influence of fires resulted in an increased relative content of the fine mode in particles size distribution, accompanied by an increase of their effective radius (Fig. 6a,b). Occasionally the coarse mode also resulted in both an increase of AOD and a decrease of AE for days exhibiting a higher number of fires. We explained the predominant impact of fine mode aerosol on the AOD increase by its longer lifetime in comparison with the coarse mode.

We also analyzed the impact of wildfires on aerosol spectral SSA at the Kyiv site during three different periods: 1) June 1-26, when the number of fires and their brightness temperature were low, 2) July 18-August 14, when the number of fires significantly increased, and 3) August 15-17, when the highest AOD values were observed. Smaller SSA values during July 18-August 14 were likely caused by an increase of the soot content in the air, transported from the wildfires. SSA and RI spectral characteristics changed during that period, increasing the absorption capacity of aerosol, especially in longer wavelengths. During August 15-17 we observed relatively large SSA values. According to Eck et al. (2009), the observed increase of SSA can explained by an increased particle size caused by wildfires, which in turn increased the total reflectance in the atmospheric column. Microphysical properties of aerosol over Kyiv under the in-

fluence of intense fires correspond well with general characteristics of biomass burning and polluted continental aerosol, as derived from AERONET sunphotometer measurements (Dubovik et al., 2002; Omar et al., 2005, 2009)..

Our comparison of AOD measurements from MODIS and AERONET showed strong functional relations between the datasets with Pearson's correlation coefficients of 0.96 for MODIS/Aqua and 0.98 for MODIS/Terra. AOD measured by MODIS is therefore well captured for the entire Ukraine. Both MODIS/Aqua and MODIS/Terra represent the aerosol content in the atmosphere over Ukraine for summer 2010 within measurement uncertainties of around 0.15 standard deviation of AOD. The spatial distribution of MODIS AOD revealed that the wildfires of summer 2010 significantly impacted the eastern, central, and southern parts of Ukraine. The AOD at 550 nm reached values of 2 (and more) at certain sites, especially in the middle of August.

Our comparison of AOD between CALIOP and MODIS revealed that the correlation coefficient was not larger than 0.6 between datasets. Over Ukraine CALIOP mainly underestimated the AOD in comparison with MODIS for the entire summer 2010. This can be explained by findings of Kittaka et al. (2011), who showed that the CALIOP algorithm likely ignores tenuous aerosol, causing an underestimation of AOD in comparison with MODIS. They also found that the aerosol layer's base height can be detected at higher altitudes, leading to an AOD underestimation.

Despite the uncertainties and sparse availability of CALIOP measurements for the time and regions we analyzed, spatial distributions of AOD from CALIOP measurements over Ukraine corresponded well with those from MODIS, in accordance with Kittaka et al. (2011). Another advantage is that CALIOP also measures at nighttime. According to CALIOP observations, the day- and nighttime AOD did not differ distinctly from each other during the analyzed period. This also corresponds to the global scale analysis of Kittaka et al. (2011).

We also analyzed aerosol profiles provided by CALIOP, which is the only source of

aerosol vertical distribution for our study. We found that the aerosol was distributed at altitudes from about 40 m to 5 km and the extinction coefficient mostly ranged from some tenth to 1 km^{-1}, although sometimes it exceeded 8 km^{-1} in very dense plumes.

Summarising, in this study we provided evidence of reasonable agreement between different types of aerosol measurements over Ukraine for the unique period in summer 2010. Further studies are needed to investigate the influence of the different fire regions on the air quality over Ukraine, which in our study could not be resolved well from the partly sparse coincidence of the datasets that are available until now. Not only other satellite instruments can be taken into account to further improve the accuracy of pollution levels analysis. The expansion of the ground-based sunphotometer network and in particular the availability of in situ observations would help, for instance, to resolve the large spatial gradients of the pollution levels that have been found over relatively densely populated areas'.
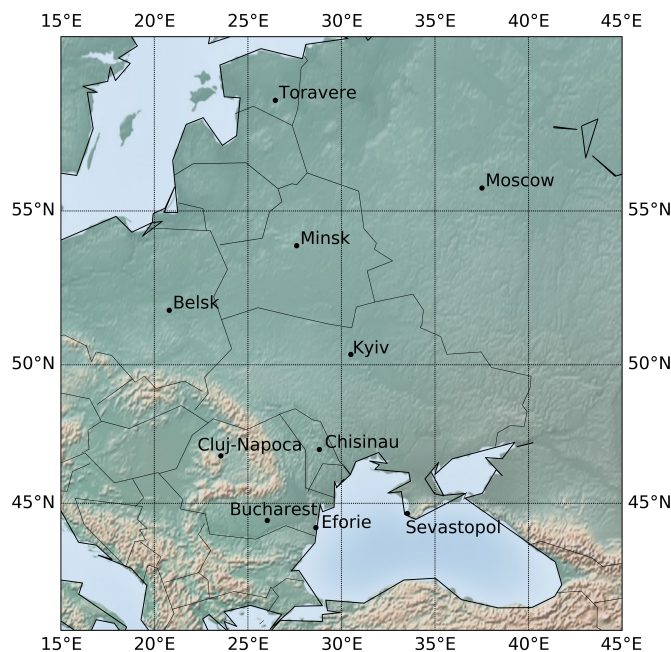
Fig. 1. AERONET observational sites in Eastern Europe and Ukraine used in this study.
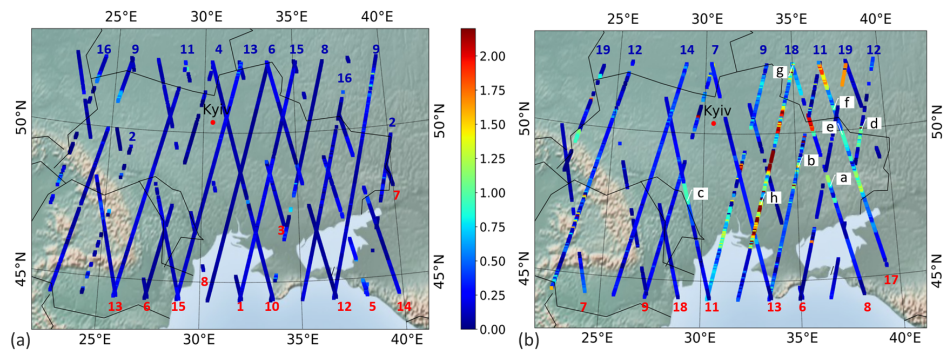
Fig. 2. AOD 532 nm distribution over Ukraine from CALIOP measurements during 16 day period from June 1 to 16 (a), from August 4 to 19 (b), 2010.