We thank the reviewers for their useful comments on the following manuscript:
Journal: ACP
Title: Assimilation of lidar signals: application to aerosol forecasting in the west mediterranean basin
MS No.: acp-2014-217
MS Type: Research Article
Special Issue: CHemistry and AeRosols Mediterranean EXperiments (ChArMEx) (ACP/AMT Inter-Journal SI)

1 Response to Referee 1's comments

Question: The paper is almost ready for publication. The authors did a good job regarding the consideration and implementations of the comments of the reviewers. One point is left: Figure 1 has to be improved. Please show only those stations that you use in your paper. You show only a part of the European lidar network (ok!), you show only a few AERONET stations in the Mediterranean(ok, but there are much more Mediterranean stations such as Potenza, Italy, and Limssol, Cyprus, and some in southern Turkey). Did you only use the indicated stations?

We showed only the measurement sites used in this paper. They provide measurements between 9 and 12 July 2012. For clarity, the caption of Fig. 1 is modified as follows:
"Locations of the different measurement sites used in this paper (see Tables 1 and 2 for the number of stations used in the different networks). The rectangular area delimited by the black box shows our modelling domain. The red triangles indicate ...".
The number of AERONET stations used in this paper is also included in Tab. 2. The following sentence is added at P. 13 L. 25-26: "Thirteen AERONET stations are used for validation in this paper (see Tab. 2)".

Yes, we used only the stations indicated in Fig. 1. We understand that there are more AERONET stations in the Mediterranean region. However, some of them are out of our modelling domain ($[15^\circ\,\mathrm{W},\ 35^\circ\,\mathrm{E}] \times [35^\circ\,\mathrm{N},\ 70^\circ\,\mathrm{N}]$), e.g. Limssol AERONET stations (34° 40' N, 33° 02' E). It is easily to check at http://aeronet.gsfc.nasa.gov. Others did not provide the Level 2.0 (cloud-screened and quality-assured) AOD data for 09-12 July 2012, e.g. Potenza station.

Question: On the other hand, you obviously show the full EMEP Europe net(why?), the full BDQA net, all EMEP Portugal/Spain, right?

No, we did not show the full EMEP network, the full BDQA nor all EMEP Portugal/Spain stations. We showed only 7 EMEP-Europe stations which are not the full EMEP network. The full BDQA network includes about 700 stations. In this paper, only about 240 stations provide data between 9 and 12 July 2012 (see Tab. 2). Therefore, only about 240 BDQA stations used in this paper were shown in Fig. 1. Also, only used EMEP-Portugal/Spain stations were shown.

Question: Did you really use, e.g., the EMEP data measured in Sweden and Scotland, why do you show these station?

Yes, we used the EMEP data measured in Sweden and Scotland to double-check if there are improvements in the northern Europe. We have stated in section 5.3 as follows: "Also, we compute the statistics of the simulation results without and with DA using daily concentrations at all EMEP-Europe stations (7 stations, green squares in Fig. 1). However, since EMEP-Europe stations are far away from the lidar network, the PM_{10} RMSE, correlation and bias are slightly but barely improved (not shown)" (P. 21 L. 19-23).

Question: Lidar stations: Black and dark-blue stars (lidar sites) can almost not be distinguished. The outside/no-data lidat stations should be indicated by an open star.

As suggested, Figure 1 has been improved. The gray star markers indicate outside/no-data lidar stations. The violet triangles indicate the stations around Barcelona, which are used in this paper. The orange diamonds indicate the AERONET stations used in this paper.

Also, the caption of Fig. 1 is modified as follows: "Locations of the different measurement sites used in this paper (see Tables 1 and 2 for the number of stations used in the different networks). The rectangular area delimited by the black box shows our modelling domain. The red triangles indicate the locations of the stations of the French air quality network (BDQA). The cyan squares indicate the locations of the stations of the EMEP-Spain/Portugal network. The violet triangles indicate the locations of the stations around Barcelona. The green squares indicate the locations of the EMEP-Europe stations. The orange diamonds indicate the locations of the AERONET stations. The dark blue/gray star markers indicate the locations of ACTRIS/EARLINET stations. The gray star markers indicate lidar stations without data between 9-12 July or outside of the forecast domain. The yellow star marker indicates the location of the Corsica lidar station. The dashed line shows the latitude of 44° N which is used to split the French stations in Sect. 5.1."

Question: AERONET stations: There are much more AERONET stations around the Mediterranean Sea (sea AERONET web page), why do you not show the complete set of Mediteranean AERONET stations?

Indeed there are a lot of AERONET stations around the Mediterranean Sea. But we think that showing the full network may confuse readers about how many stations were exactly used in this paper and which subset of stations were used, etc. Figure 1 shows the locations of the stations used in the different networks. Tables 1 and 2 indicate the number of stations used in the different networks.

Question: You use the AERONET data from Poland,Ukraine, and Black Sea area? Why are these stations shown which are far away from the Mediterranean? So, Figure 1 needs to be improved!.

No, we did not use the AERONET data from Poland, Ukraine and Black Sea area. We used only 13 AERONET stations around the Mediterranean Sea. We stated this point in section 5.4 as follows: "..., where only 13 AERONET sta-

tions being leeward and close to the lidar network are considered (see Fig. 1)". In the ACPD version online http://www.atmos-chem-phys-discuss.net/14/13059/2014/acpd-14-13059-2014.pdf, only 13 used AERONET stations were shown in Fig. 1. Therefore, it was a mistake of the figure inserted in the revised manuscript. It is now corrected.

2 Response to Referee 2's comments

Question: Thanks for the work in addressing the reviewers' comments. To further improve readability please consider not always referring to previous work (i.e. Wang at al 2014), but actually explaining a bit more in the text. Some readers may just want to read this one paper, so it needs to stand on its own. Please also consider submitting similar work in "parts" (i.e. Part 1, Part 2, etc.) at least the reader knows that this is a series of papers on the same subject with different emphasis.

As suggested, we modified the manuscript and added more explanations rather than referring to Wang et al., 2014. The following list details our corrections:
1) The following sentence is removed from P. 8 L. 16: "The DA algorithm developed by [Wang et al., 2014] based on OI for assimilating PR^2 is employed".

2) The statement "[Wang et al., 2014] developed an aerosol optical property module to simulate the aerosol optical properties (AOD, backscatter and extinction coefficients) and lidar signals (PR^2) from the model aerosol concentration outputs" is modified as follows:
"The aerosol optical property module developed by [Wang et al., 2014] is employed. It simulates the molecular backscatter and extinction coefficients (β_m and α_m) from the Boltzmann constant, the atmospheric pressure and temperature. The aerosol extinction and backscatter coefficients (β_a and α_a) are simulated from the model aerosol concentration outputs (i.e. aerosol water content and aerosol) by estimating the particle wet diameter and the aerosol complex refractive index of particle. Lidar signals (i.e. PR^2 normalised at a reference altitude) and AOD are simulated as functions of the molecular backscatter and extinction coefficients and the aerosol extinction and backscatter coefficients" (P. 9 L. 9-16).

3) The sentence "They also detailed the OI approach for assimilating lidar signals from the model aerosol concentration outputs. The analysed mass concentrations $\mathbf{x}_a$ is obtained from the equation ..." is modified to "The OI approach is used for assimilating lidar signals from the model aerosol concentration outputs [Wang et al., 2014]. The analysed mass concentrations $\mathbf{x}_a$ is obtained from the equation ..." (P. 10 L. 5-7).

4) The sentence "H is the observation operator that simulates normalised PR^2 from the mass concentrations $\mathbf{x}_b$ through the module of PR^2 simulation developed in Polair3D [Wang et al., 2014]" is modified to "H is the observation operator that simulates normalised PR^2 from the mass concentrations $\mathbf{x}_b$" (P. 10 L. 10-11).

5) The statement "For the specification of the background and observation error covariance matrices, we refer to [Wang et al., 2014]. We set the background error of

$PM_{2.5}$ and $PM_{10-2.5}$ to be $5\,\mu g\,m^{-3}$ and $30\,\mu g\,m^{-3}$ respectively in $\mathbf{B}$, since the model simulates more accurately $PM_{2.5}$ than $PM_{10-2.5}$ (see Sect. 5). We take $\mathbf{R} = \sigma^2\,\mathbf{I}$ [Wang et al., 2014], where σ is an observation standard deviation (depending on instrumental and representativeness error variances) and $\mathbf{I}$ is the identity matrix in the observation space" is modified as follows:
"We set the background error covariance matrix as a block diagonal matrix having two main diagonal blocks. One main diagonal block is set as the background error variance matrix of $PM_{2.5}$. Another is set as the background error variance matrix of $PM_{10-2.5}$. We set the background error of $PM_{2.5}$ and $PM_{10-2.5}$ to be $5\,\mu g\,m^{-3}$ and $30\,\mu g\,m^{-3}$ respectively in $\mathbf{B}$, since the model simulates more accurately $PM_{2.5}$ than $PM_{10-2.5}$ (see Sect. 5). We take $\mathbf{R} = \sigma^2\,\mathbf{I}$, where σ is an observation standard deviation (depending on instrumental and representativeness error variances) and $\mathbf{I}$ is the identity matrix in the observation space" (P. 10 L. 19-26).

6) The sentence "The altitude of normalisation was diagnosed as explained in [Wang et al., 2014]" is modified to
"It is because there is almost no aerosol in the molecular zone. The linear approximation of the observed lidar signal should be equal to the one of the simulated molecular signal (without aerosol contribution) in the molecular zone [Wang et al., 2014]" (P. 12 L. 28 and P. 13 L. 1-3).

7)The statement "The hourly AOD data at 355 nm are derived by Level 2.0 (cloud-screened and quality-assured) AOD data at 340 and 380 nm retrieved from AERONET (AErosol RObotic NETwork, http://aeronet.gsfc.nasa.gov/) following the Ångström law. The procedure was described by [Wang et al., 2014]" is modified to
"The hourly AOD data at 355 nm are derived by Level 2.0 (cloud-screened and quality-assured) AOD data at 340 and 380 nm retrieved from AERONET (AErosol RObotic NETwork, http://aeronet.gsfc.nasa.gov/) following the Ångström law [Wang et al., 2014]" (P. 13 L. 20-22).

8) P. 23 L. 23-24 "(Wang et al., 2014)" is modified to "(see sections 2 and 5)".

Thank you very much for your advice. We will consider submitting similar future work as Part 1, Part 2, etc.

References

[Wang et al., 2014] Wang, Y., Sartelet, K. N., Bocquet, M., and Chazette, P. (2014). Modelling and assimilation of lidar signals over Greater Paris during the MEGAPOLI summer campaign. *Atmos. Chem. Phys.*, 14:3511–3532.