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Interactive Comment

Interactive comment on "Analysis of a strong wildfire event over Valencia (Spain) during Summer 2012 – Part 1: Aerosol microphysics and optical properties" *by* J. L. Gómez-Amo et al.

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Anonymous Referee #1 Received and published: 25 October 2013 General comments: This paper presents measurements of aerosol microphysical and optical properties for the largest wildfire in Eastern Spain since 2004. Column-integrated, vertically resolved, and surface observations of biomass burning aerosols are described. The inversion method and Mie theory are used to retrieve aerosol microphysical and optical parameters. The results show high PM2.5 concentration, aerosol optical depth, Angstrom exponent, and aerosol scattering of the fire plumes that can substantially contribute the air pollution of the studied region. The measured and retrieved data are valuable

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to the biomass burning aerosol database. However, I am concerned of publishing this paper on ACP due to the following reasons:

Despite the extensive data, this paper lacks a clear focus. It is difficult to summarize the new scientific findings of the paper, i.e., besides reporting the data and showing that the values are high during the fire period, which is expected and not surprising, what can we learn from these measurements? In addition, the measured parameters are not synthesized but described individually. These points are reflected in the text and the figures: Only results are shown and the discussion section is absent; many figures merely show time series of different parameters. In-depth analysis is needed. I do find there are some interesting points to focus on, e.g., the co-existence of dusts and fire smokes, but the related discussion is scattered in the results so a distinguished point is not made. Another way to strengthen this paper is to extend it to include the quantitative radiative impact of the wildfire, which will address the highly uncertain climate forcing of wildfires. The paper is not well organized. First, some result parts describe how the parameters are calculated. Such description should be moved to the method section. For example, the inversion strategies in section 4.4 can be discussed in the method section. See more in the specific comments. Second, sections 4.1, 4.5, 4.6 discuss column-integrated observation, while sections 4.2 and 4.3 discuss vertical structure and surface measurements, respectively, it is better to discuss column-integrated observation and then the rest or vice versa. Moreover, each sub-section of section 4 describes the day-by-day variation of certain parameters, resulting in a lot of repeated discussion and redundancy. It is also difficult to follow. I suggest organize the results and the discussion by the pollution events, i.e., aerosol classification in section 4.4, not by measured parameter. This way the measurements can be integrated and properties of each pollution period can be clearly addressed.

We acknowledge the reviewer for the comments and suggestions regarding this paper.

REORGANIZATION: As the reviewers suggested the paper has been completely reorganized in order to give a more synthetic[A1] and direct information about the data

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used and the scientific results achieved in this analysis. In that sense, the introduction has been modified in order to highlight the objectives of this study. In addition, the new version of the paper will be substantially shortened. In particular, the vertical structure and boundary layer dynamics (Sect. 4.2) and the surface measurements (Sect. 4.3) sections have been removed since they were mainly a detailed description of the temporal evolution of the event. Moreover, the analysis of the aerosol properties has been integrated and discussed by pollution events as the reviewer suggested. In addition, a new section dealing with the investigation of the co-existence of mineral dust and smoke aerosols will be added to the new version of the manuscript. We agree with the reviewer that the quantitative radiative impact of this event would be helpful to address the climatic uncertainties associated to wildfire smokes. However, the radiative impact of this wildfire event will be quantified in a future work. We think that the explanation of the characteristics of the instrumentation and data, the radiative transfer simulations and the methodology used in the retrieval will enlarge too much the paper and remain out of the new objectives of the reviewed paper.

FOCUS and OBJECTIVES The reviewed version of the paper will be focused on the determination of the column-integrated microphysics and optical properties of the aerosols types identified during the wildfire event. Special attention is paid to the extremely fresh biomass burning and mineral dust particles, since they are the main aerosol species contributing to the aerosol load during the wildfire episode. In addition, the possible mixing between them and the effects on the aerosol microphysical and optical properties of the mixture have been addressed as one of the main objectives of the paper. MOTIVATION This study investigates the extremely intense wildfire event and in particular the aerosol properties of fresh smoke plumes very close to the sources in a Mediterranean environment. There is a lack of this information in the Mediterranean region, despite biomass burning aerosols constitute one of the largest source of particles which have a significant influence on the regional radiative budget. The strong intensity of the observed smoke plume that reached extremely high AOD values provides a unique opportunity to approach this issue.

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METHODOLOGY In addition, we propose the use of the combination of direct-sun observations by a Cimel CE-318 sun-photometer with the inversion methodology proposed by King et al., (1978) and the Mie theory together with the standard AERONET inversions to continuously monitor the aerosol properties during the event. This integrated methodology is found to be an interesting alternative to detect quick changes in the aerosol properties during the strongest aerosol episodes. This information cannot be correctly retrieved by using only the standard AERONET inversion algorithm mainly due to the lack of symmetrical sky radiances needed for the inversions during these episodes and the limited temporal resolution of the sky-radiance measurements (30-60 minutes). Therefore, alternative methodologies are needed to address this challenge.

Specific comments: 1. The abstract typically contains no more than two paragraphs. Please follow the requirement of ACP: “The abstract should be intelligible to the general reader without reference to the text. After a brief introduction of the topic, the summary recapitulates the key points of the article and mentions possible directions for prospective research.”

Following the suggestions of the reviewer and requirement of ACP the abstract will be shortened and synthesized in the revised version of the paper.

2. Meteorological situation: The fire is 60 km from the sampling site, so wind direction will be more useful to identify the infiuence of fire plume on the sampling site. The back trajectory does not support the data analysis and is not discussed later in the text. The related discussion and Figure 1 are redundant.

Figure 1 (back-trajectories) will be removed in the reviewed version of the manuscript and wind speed and direction have been analysed independently for each pollution event observed during the studied period.

The following discussion will be added in the Meteorological situation section of the reviewed version of the paper:

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Wind direction and speed have been analysed independently for each of the pollution events observed during the studied period. The data from the Burjassot station with 10-minutes temporal resolution and the ECMWF reanalysis wind profiles every 6 h have been used to study the wind field at surface and at different pressure levels, respectively. Figures 1 and 2 of this document show the wind roses at surface and 800 hPa (~2000 m) for the different periods defined from 24 June to 4 July. Surface winds were stable during the entire period of the analysis with a maximum speed of 5 m/s at noon and nighttime minima. In addition, the westerlies winds were persistent during the entire period of analysis and display low speed of 3-4 m/s with some peak larger than 4 m/s. Conversely, some differences between the periods were observed for the wind at 800 hPa level. Weak southerly winds from observations during the SBG period. However a progressive change in wind direction towards northeast together with an increasing wind speed was observed during the DDE and FSK periods. No significant changes were found in the wind speed and direction at 850, 800 and 700 hPa (~1000, 2000 and 3000 m altitude). Therefore, the persistent wind direction and the moderately high wind speed favored the aerosol transport from the Southeast and both, mineral dust and the smoke plume reaching the station were linked to wind variations during DDE and FSK periods. The wind speed of 15-20 m/s for the FSK period allowed that the smoke plume reached the Burjassot station in less than 1 hour. The wind speed weakened during the RSK period and the southerly wind component was prevalent.

3. P22649 "On 28 June, the effect of the dust layer reduces the surface contrast (Fig. 2a), while the magnitude of the wildfire can be clearly observed on 29 June (Fig. 2b)." The dust layer still existed on 29 June, so more explanation of the difference is needed.

Section 3. Meteorological situation will be substantially modified in the new version of the manuscript and a similar discussion as follows has been included in the manuscript.

The Saharan dust event can be clearly observed in Figure 3 (of this document), which shows the MODIS images on 28, 29 and 30 June over Eastern Spain. The burn[A2]ing area is displayed in red. The effect of the dust layer reduces the surface contrast over

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North Africa and the Iberian Peninsula for the three days. On 28 June, the dust layer affected the entire Iberian Peninsula while some displacement towards the Mediterranean coast of Spain is observed on 29 and 30 June. Moreover, the wildfire effect changes throughtout the episode duration, since the outbreak on 28 June at Cortes de Pallás (Fig. 3a). The smoke plume can be clearly distinguished over the dust layer on 29 June following the prevailing Northeastern wind direction (Fig. 3b). The second wildfire outbreak was on 29 June at Andilla and the magnitude of the combination of both emission sources can be completely observed on 30 June, which was largely extended over the Western Mediterranean (Fig.3c).

4. P22649, "The AOD and AE values ranged between 0.14-0.16 and 1.1–1.15", the 0.14-0.16 is really not a range. The AE range is 1.5 not 1.15.

This sentence will be rewritten in the new version of the manuscript as follow: "The AOD and AE display average values of 0.148 and 1.13, respectively . . ."

5. P22649, "indicating the presence of larger particles in the atmosphere", add a reference to this statement.

There is a lot of literature dealing with the link between the Angström exponent and the size distribution (e.g. Eck et al., 1999; Dubovik et al., 2002; Schuster et al., 2006). These references will be added in the new version of the manuscript.

Eck, T. F., B. N. Holben, J. S. Reid, O. Dubovik, A. Smirnov, N. T. O'Neill, I. Slutsker, and S. Kinne (1999), Wavelength dependence of optical depth of biomass burning, urban, and desert dust aerosols, J. Geophys. Res., 104, 31,333– 31,349. Dubovik, O., B. N. Holben, T. F. Eck, A. Smirnov, Y. J. Kaufman, M. D. King, D. Tanre′, and I. Slutsker (2002), Variability of absorption and optical properties of key aerosol types observed in worldwide locations, J. Atmos. Sci., 59, 590– 608. Schuster, G. L., O. Dubovik, and B. N. Holben (2006), Angstrom exponent and bimodal aerosol size istributions, J. Geophys. Res., 111, D07207, doi:10.1029/2005JD006328.

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6. Section 4.2 the boundary layer dynamics can be move to meteorological conditions. And P22651, Line 19-26 describes the calculation of the boundary layer height and can be moved to the method section.

The vertical structure and boundary layer dynamics (Sect. 4.2) will be removed in the new version of the paper since it remains out of the objectives of the reviewed paper. See next answer for more information about it.

7. Section 4.2, the mixing layer height calculated from the HYSPLIT model is highly uncertain. Therefore, the HYSPLIT-derived mixing layer height should be justified by comparing with the mixing layer height from the Lidar measurements before being used.

As far as we know, there is no specific literature regarding to the uncertainties of the boundary layer determination from HYSPLIT[A3]. However, Garcia et al., 2007 showed that the mixing layer height from HYSPLIT agreed well with a Lidar DIAL during a 2 months campaign in Segovia (Spain), with a correlation coefficient of 0.7. Meteorological models base the retrieval of the boundary layer height on vertical differences in the temperature. These models do not take into account the temperature variations due to the aerosol radiative effect. In case of severe aerosol events, as in the case studied in this work, these temperature changes may be important causing larger uncertainties in the determination of the boundary layer height. In addition, the retrieval of the boundary layer can be highly uncertain, even if it is determined from lidar measurements, when several aerosol layers are present in the lower troposphere. A complex vertical aerosol structure and high wind speed conditions can alter the vertical dynamics making difficult an accurate determination of the boundary layer height (e. g. Seibert et al., 2000). A comparison between the boundary layer height obtained by two different models (HYSPLIT and the European Center of Medium Wether Forecast (ECMWF) reanalysis) with that retrieved from the measurements of our lidar using the gradient method (e.g. Seibert et al., 2000) is shown in Fig. 4 of this document. This comparison highlights that the differences in the boundary layer height between models and lidar measurements are really important during the studied event. In addition, differences between the results provided by both models are not negligible. As a result, we think that is not possible to determine the boundary layer height with the desired accuracy and consequently the vertical structure and boundary layer dynamics (Sect. 4.2) and its related discussion will be removed in the new version of the paper.

Seibert, P., F. Beyrich, S.E Gryning, S. Jore, A. Rasmussen, P. Tercier, Review and intercomparison of operational methods for the determination of the mixing height. Atmospheric Environment 34 (2000) 1001-1027

8. Section 4.3, it is easier to show diurnal plots when discussing diurnal cycles.

We agree with the reviewer. However, the Surface measurements section, in which diurnal cycles were discussed, will be removed in the revised version of the manuscript.

9. Section 4.4 the first 2 paragraphs and the 4th paragraph are largely describing method, so they can be moved to the method section.

A method[A5]ology section will be added in the revised version of the manuscript containing the information of current section 4.4.

10. The retrieved size distribution (Figure 7) is problematic: It is surprising that the coarse mode of smoke (2-3 um) is larger than the coarse mode (1-2 um) of dust. Why is that?

The median radius and volume of the coarse mode aerosol are mostly related with particles of local origin. Due to their larger size, they usually sediment faster than finer particles and their transport is limited to certain atmospheric conditions. However in case of strong wildfire conditions, the intense flaming and combustion cause a fast increase of the air temperature near the surface. These high temperatures trigger a strong convection which may transport a lot of particulate matter to the higher layers of the atmosphere. Most of this matter is made up of aggregates of carbon, ashes and unburnt material portions (Reid et al., 2005) with larger size that can be also transported to large distances and detected in remote places. In our case, the sampling site is very close to the wildfire source. Moreover, a moderately high wind speed (∼ 15 m/s) in the higher atmospheric layers allowed the fast displacement of the smoke plume which reached the Burjassot station in less than 1 hour. Therefore, the coarse mode of this extremely fresh biomass burning material may be made up of a notable amount of the larger size particulates that can explain the high median radius of the coarse mode obtained. In addition, Dubovik et al., (2002) reported climatological averaged values of coarse median radius for the smoke aerosols that in general were larger than 3 um. Conversely, the median radius reported for the dust cases varied between 1.90 and 2.7 um.

11. Technical corrections: 1. P22640, Line 5, vertical resolved -> vertically resolved 2. P22640, Line 17, define AOD 3. P22641, Line 25, both on -> on both 4. P22641, Line 25, as -> and 5. P22641, Line 26, consists on -> consists of 6. P22642, Line 1, on -> of 7. P22642, Line 2, remove space in “10 %”. 8. P22642, Line 17, in example -> for example 9. P22642, Line 19, Eck, 2001 -> Eck et al., 2001 10. P22642, Line 26, add “,” after “areas” 11. P22643, Line 6, impact in -> impact on 12. P22644, Line 3, monitor -> monitoring 13. P22650, Line 21, ratio -> fraction 14. P22651, Line 16, are -> is

As we mentioned before, the revised version of the paper has been completely reorganized and rewritten in most of its parts. Therefore the technical corrections will be addressed as much as possible.

Figure captions:

Figure 1. Frequency diagram of wind speed and direction at surface level for each aerosol period identified during the wildfire episode: a) summer background (SBG); b) dust (DDE); c) smoke (FSK) and; d) residual smoke (RSK).

Figure 2. Frequency diagram of wind speed and direction at 800 hPa level (∼2000 m) for each aerosol period identified during the wildfire episode: a) summer background (SBG); b) dust (DDE); c) smoke (FSK) and; d) residual smoke (RSK).

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Figure 3. MODIS images on: a) 28 June (MODIS Terra); b) 29 June UTC (MODIS Aqua); c) 30 June (MODIS Aqua) and d) Zoom image on 30 June (MODIS Aqua) including Burjassot site (black) and the wildfire sources at Cortes de Pallás (yellow) and Andilla (blue).

Figure 4. Boundary layer height determined by HYSPLIT (yellow line) and ECMWF reanalysis (red line) models, and by the gradient method using the lidar signal. Two different threshold values for the application of the gradient method were used (green and pink lines).

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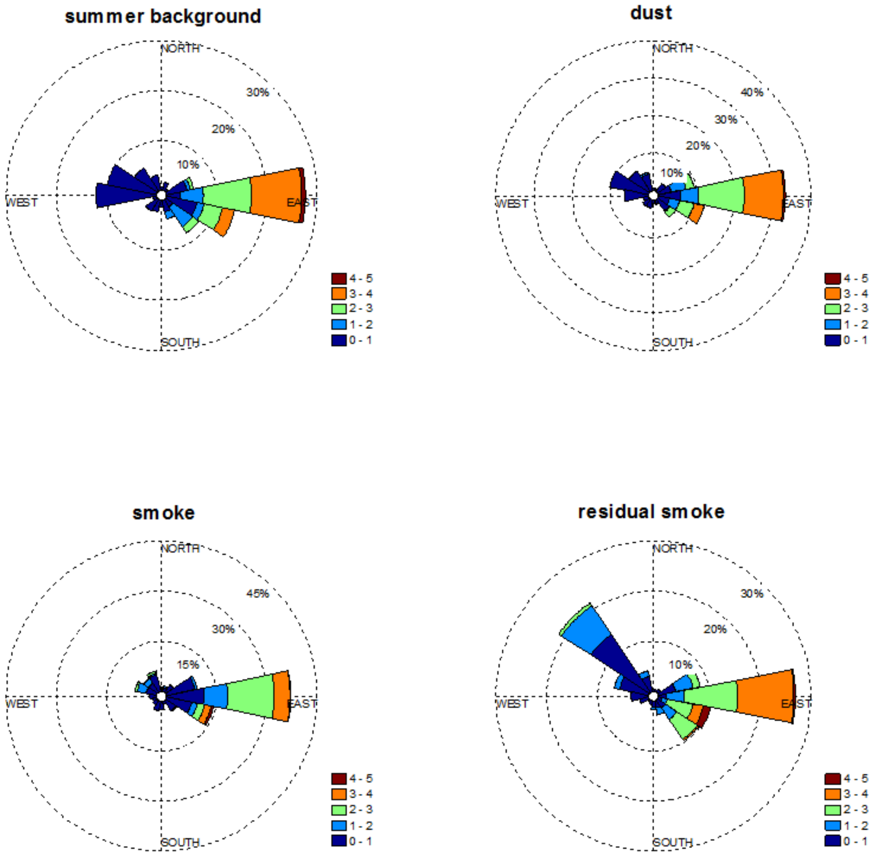

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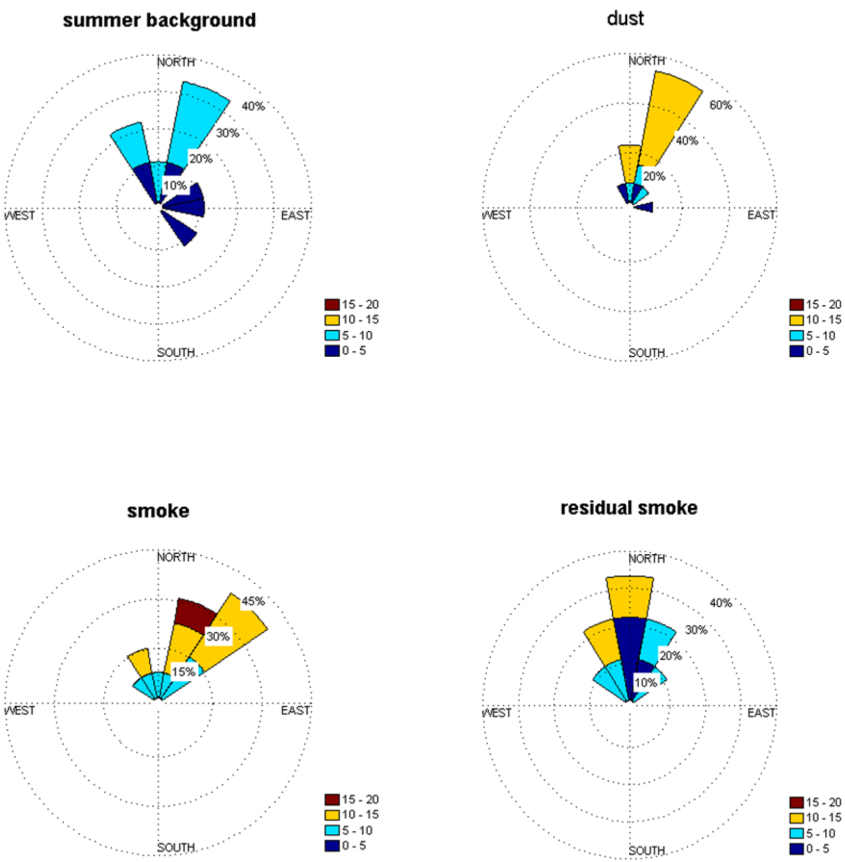

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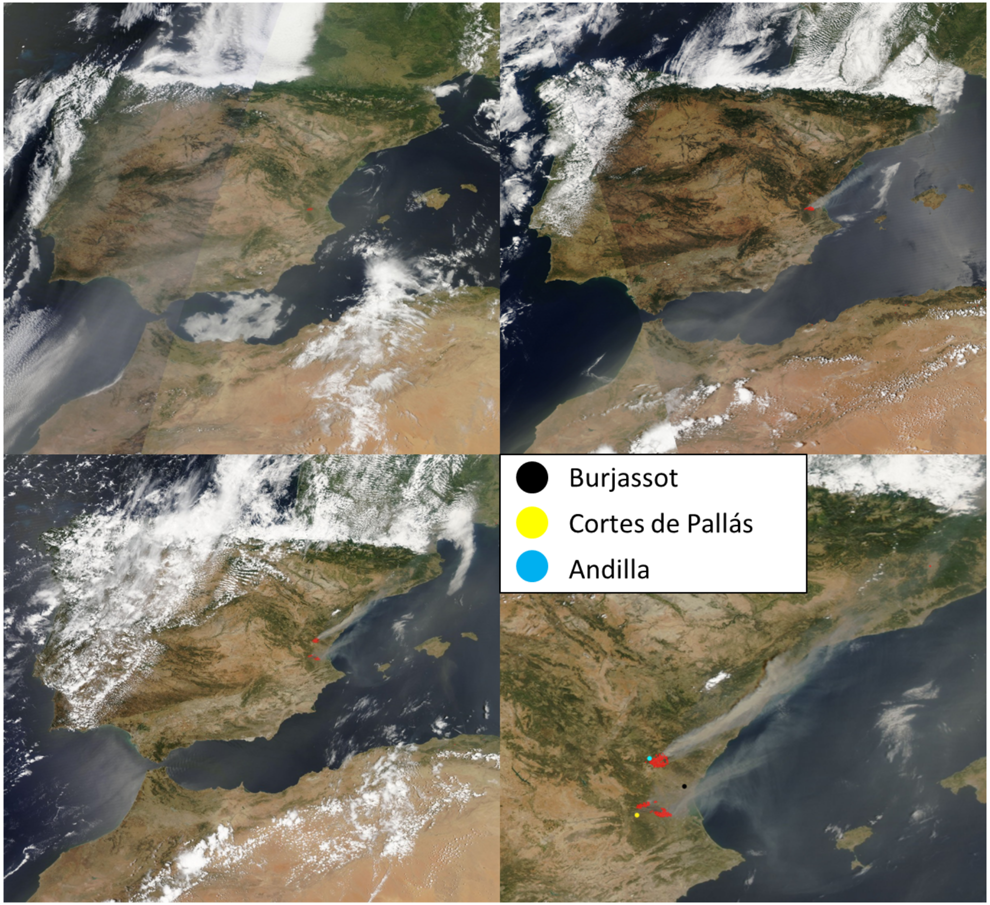

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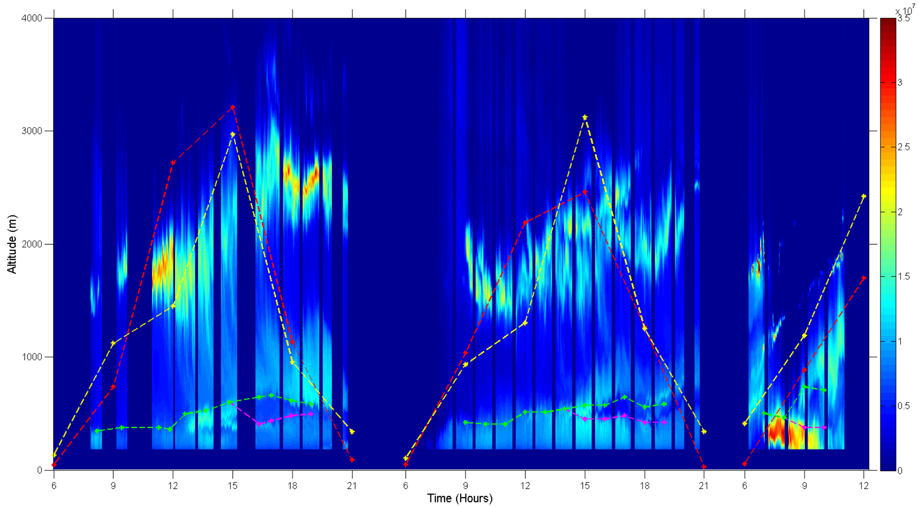

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