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Atmospheric Chemistry and Physics
Discussions

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.

J. L. Gómez-Amo et al.

jlgomeza@uv.es

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Anonymous Referee #2 Received and published: 24 December 2013 General comments: The authors presented a detailed account of wildfire event occurred in 2012 at Eastern Spain. Authors studied surface, vertical and columnar aerosol properties using ground based instruments and satellite derived data. High values of PM 2.5, AOD, AAE and scattering coefficients are observed during the event. PM 2.5 concentrations observed are higher than EU standards showing the intensity and extend of wildfire. Authors reported many observed and derived parameters in this study. But I have following reservations:

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

1. The study conducted does not have specific instruments/methods which can confirm the burning events other than visual observation of plumes from the burning.

The study has been carried out using the standard instruments in the Burjassot station which are mainly devoted to aerosol characterization. Therefore in the first step, the confirmation of the event was done from the methods usually used to identify the aerosol type in the atmosphere by means of column-integrated measurements (AOD and AE). This method is widely used in the aerosol classification when remote sensing techniques are used (e.g. Pace et al, 2006). In addition, a lot of ancillary information was also used in order to assure the cloud screening process (e.g. all sky camera and MSG/SEVIRI images), the airmass origin (backtrajectories) and also MODIS images which allow to visually confirm the dust event on 26-28 June, and the arrival of the smoke plume and its extension on 29-30 June. In addition, the wind speed and direction analysis will be included in the revised version of the manuscript in order to get more information about the aerosol origin. See the answer to the Technical question number 4. Therefore the visual information has been used only as a confirmation of the event

2. No filter sampling is reported during this study. Analysis of filters before and after the burning might have provided good characterization of chemical properties of aerosols. We agree with the reviewer. It would have been interesting to have these measurements. Unfortunately there are no filter measurements devoted to the chemical characterization in the station. Consequently, the aerosol chemical composition was not available during the event.

3. This study is also silent on the absorption during the burning event. High scattering coefficient is associated with the plumes from burning event. But some part of this scattering may be also contributed from local sources such as sea sprays considering the proximity of sampling location to sea.

Routinely observations of in situ aerosol absorption are done by an aethalometer deployed in the Burjassot station. These measurements would have been really useful in the analysis and comprehension of the fire event. However, the aethalometer was on its calibration period during the event, far from the measuring station. Unfortunately the absorption data were not available during the event. The only information about the aerosol absorption was provided by means of the Aeronet inversions throughout the event, in which the complex refractive index is routinely determined. In this work, the aerosol absorption was analysed by means of the aerosol single scattering albedo throughout the entire studied period. It is the magnitude commonly used to address the aerosol absorption when column-integrated measurements are used (e.g. Dubovik et al., 2002). On the other hand, part of the scattering can be indeed due to the contribution of local sources (sea spray and terrain). However, extraordinary high values of AOD, scattering coefficient at surface and PMx concentrations were measured and they were widely overcome by a factor of 40, 27, 7 respectively the usual values measured in the station. Therefore we state than the contribution from other aerosol sources different to the smoke and dust particles should not be so important, especially during the most intense portion of the event. In addition, the analysis of the wind direction confirms that the wind blew from southwest during the most intense part of the event (dust and fresh smoke periods) suggesting that such drastically increase observed in the surface measurements was largely due to the contribution of the mineral dust and biomass burning particles. See the answer to the Technical question number 4 for additional information about the wind analysis.

4. All parameters reported by the authors are well known in the case of a wildfire event. This study is lacking in depth analysis of the observed data. The climatology of microphysical and optical properties of biomass burning aerosol in the most important global emission sources has been studied from observations by the AERONET network (e.g. Eck et al., 2001; Dubovik et al., 2002) and from situ measurements. Moreover, long range transport of aged biomass burning aerosols has been characterized by lidar and satellite observations (e.g. Müeller et al., 2007; Pace et al., 2005). However,

there is a lack in observations of the aerosol microphysical and optical properties of fresh smoke plumes near the sources in the mid-latitudes (Alados-Arboledas et al., 2011), especially in the Mediterranean region, where the warm and dry climate favors the ignition and spread of wildfires during summer season. These biomass burning aerosols constitute a great source of particles in the Mediterranean, and together with the frequent mineral dust events significantly influence the regional radiative budget (e.g Di Biagio et al., 2009). Therefore additional information about these properties, the vertical distribution of the fresh smoke plumes as well as its state of mixture is needed to improve the performance of regional climate models (Sicard et al., 2012). Due to these reasons and to strength the impact of the paper a new data treatment has been added in the new version of the manuscript dealing with the study of the aerosol mixture.

Eck, T. F., Holben, B.N., Ward, D.E., Dubovik, O., Reid, J.S., Smirnov, A., Mukelabai, M.M., Hsu, N.C., O'Neill, N.T. and Slutsker, I., Characterization of the Optical Properties of Biomass Burning Aerosols in Zambia during the 1997 ZIBBEE experiment, J.Geophys.Res., 106, 3425-3448, 2001. Dubovik, O., Holben, B., Eck, T.F., Smirnov, A., Kaufman, Y.J., King, M.D., Tanré, D., and Slutsker, I, Variability of absorption and optical properties of key aerosol types observed in worldwide locations Journal of the Atmospheric Sciences 59 (3), 590-608, 2002. Di Biagio, C., di Sarra, A., Meloni, D., Monteleone, F., Piacentino, S. and Sferlazzo, D., 2009, Measurements of Mediterranean aerosol radiative forcing and influence of the single scattering albedo, J. Geophys. Res., 114, D06211, doi: 10.1029/2008JD011037. Müller, D., I. Mattis, A. Ansmann, U. Wandinger, C. Ritter, and D. Kaiser, Multiwavelength Raman lidar observations of particle growth during long-range transport of forest-fire smoke in the free troposphere, GEOPHYSICAL RESEARCH LETTERS, VOL. 34, L05803, doi:10.1029/2006GL027936, 2007 Pace, G., D. Meloni, and A. di Sarra (2005), Forest fire aerosol over the Mediterranean basin during summer 2003, J. Geophys. Res., 110, D21202, doi:10.1029/2005JD005986 M Sicard, M Mallet, D García-Vizcaíno, A Comerón, F Rocadenbosch, P Dubuisson and C Muñoz-Porcar, Intense dust and extremely fresh biomass burning outbreak in Barcelona, Spain: characterization of their optical properties and estimation of their direct radiative forcing, Environ. Res. Lett. 7 (2012) 034016, doi:10.1088/1748-9326/7/3/034016

5. The authors should study the inter relationship between the observed parameters. In deep analysis and discussion of the data will be added in the revised version of the paper.

6. Most of the plots show time series of observed data which is very simple to produce.

We agree with the reviewer, the time-series are simple to produce. However the time-series of several measured and derived parameters provided valuable information about the evolution and changes in the aerosol properties throughout the event. In fact, it allows determining the instant in which the smoke plume reaches the Burjassot station and how it evolves. In addition, rapid changes in AOD and AE were really helpful to confirm the co-existence of dust and smoke particles during the event. These time-series plots will be reduced to the meaningful minimum in the reviewed paper.

7. Authors need to bring in a section about the methods used in this study. Currently methods and results are mixed inside the literature. As the reviewer suggested, a new section dealing with the methodology used in the paper will be added in the revised version.

Specific comments: 1. Page no: 22640, line no: 22, Why the unit of volume concentration is in μm3 μm-2

The volume concentration for the column-integrated aerosol size distribution is commonly expressed in (μm3 μm-2). It means the volume of the particles integrated over an entire atmospheric column of a 1 μm base area. One can find these units in all works dealing with AERONET size distributions (e.g Dubovik et al., 2002).

2. Specify the type of instrument/method used to measure PM mass for the study

PM2.5 is measured automatically by a Beta Attenuation Method (BAM) instrument.

This method consists in the attenuation of beta particles through a filter as it gets loaded. Beta particles are emitted from a small source of 14C coupled to a sensitive detector that counts them before and after they interact with the filter. The difference between the two measurements is related to the mass concentration by application of the Beer's Law. As the mass deposited on the filter increases, the measured beta counts are reduced.

3. Indicate the location of Cortes de Pallás and Andilla in Figure no: 2

The location of Cortes de Pallás and Andilla will be added to Figure 2. See figure 3 of this document.

4. What is the wind velocity and direction during the biomass burning events? As the reviewer suggested, the analysis of the wind speed and direction has been included in Sect. 3 in order to better explain the particle origin and transport during the event.

The following discussion will be added in the Metereological situation section of the revised version of the paper:

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.

5. Page no: 22645, line no: 15, Explain the abbreviation "MSG/SEVIRI" mentioned

The abbreviation is referring to the Spinning Enhanced Visible and Infrared Imager instrument, onboard of Meteosat Second Generation satellite (MSG/SEVIRI). It will be added in the revised version of the paper.

6. What is the ambient humidity during measurement? Did nephelometer data has any effect on humidity?

Since we don't have measurements of the hygroscopic growth factor f(RH), which quantifies the influence of RH on the scattering coefficient, on our site, we have been unable to check the influence of relative humidity on the scattering coefficient. However, we expect to be able to make this kind of measurements soon because of the importance of hygroscopicity in our region. In our case, as stated in the manuscript, the measurements were made at ambient relative humidity, although the relative humidity measured within the nephelometer chamber is lower than the ambient RH due to the heating of the lamp. The ambient relative humidity was mainly in the range 60 – 90 % (with a mean value of 74 $\pm$ 13% for the whole period), while the relative humidity measured within the nephelometer chamber was in the range 25 – 65 % (with a mean value of 62 $\pm$ 12% for the whole period). Around this value of RH, the scattering coefficient shows a minimum or slow increase with RH (Anderson and Ogren, 1998; Xu et al., 2002).

Xu, J., Bergin, M.H., Yu, X., Liu, G., Zhao, J., Carrico, C.M., Baumann, K., 2002.

Measurement of aerosol chemical, physical and radiative properties in the Yangtze delta region of China. Atmospheric Environment 36, 161e173.

Anderson, T.L., Ogren, J.A., 1998. Determining aerosol radiative properties using the TSI 3563 integrating nephelometer. Aerosol Science and Technology 29 (1), 57e69.

7. Figure 2 can be modified with a MODIS fire count map which can show the biomass burning locations. The current figure 2 will be changed by a new MODIS figure including the burning area in the revised version of the paper. This figure will include also the location of Burjassot station and the fire sources at Cortes de Pallás and Andilla. See figure 3 of this document.

8. Page no: 22651, line no: 12, "The sudden variation in the AOD and AE was related with changes in the wind direction and speed that varied the smoke load reaching Burjassot". Prove this statement with some wind direction and velocity at the sampling location.

Fig.1 and 2. of this document show the wind roses at surface and at 800 hPa (∼2000 m), including wind speed and direction. In addition, Figure 4 of this document shows the time series of speed and direction at surface (10-minutes resolution) and 800 hPa during the event. Some variations in the wind direction are observed in the surface measurements during the morning on 29 and 30 June. The higher concentration of smoke was located above the 1500m altitude and the variations in the surface wind could not have any influence on aerosol load. The wind speed and direction at 800 hPa during the event have been also plotted in the figure. However its low resolution (6 h) does not allow detecting sudden wind variations. Figure 5 of this document shows the images of the all sky camera at 7:45, 8:20 and 10:15 UTC on 29 June. The images clearly show that there was a smoke cloud over Burjassot at 7:45 UTC which disappears after several minutes and it was not observed at 8:20 UTC. The smoke cloud was observed again later (10:15 UTC) . In addition, the image at 8:20 UTC shows that the sky was not totally clear (blue) because of the persistent dust influence. In addition, the changes in the AOD and AE may be also related to variations in the particle emission rate at the fire sources which could vary the amount of biomass burning aerosol reaching the sampling site. These variations may cause inhomogeneities in the smoke plume that can be reflected in the AOD and AE. This discussion will be added in the revised version of the paper.

9. What is the error associated with the measurement of mixing layer height from HYSPLIT? Give this error as error bars in Figure No: 4

As far as we know, there is no specific literature regarding to the uncertainties of the boundary layer determination from HYSPLIT. 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. 6 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.

P. Seibert, 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

Technical corrections: 1. Page no: 22641, line no: 10, Modify the sentence “These wildfires. . .. . .emission source” The sentence will be rewritten in the revised version of the paper.

Comments regarding to the revised version of the paper

REORGANIZATION: As the reviewers suggested the paper has been completely reorganized in order to give a more synthetic and direct information about the data 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 #1 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..

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 were 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.

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 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 the standard AERONET inversion algorithm mainly due to a lack of symmetry in the sky radiance 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.

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).

Figure 3. Modis quick response images on: a) 28 June (MODIS Terra); b) 29 June UTC

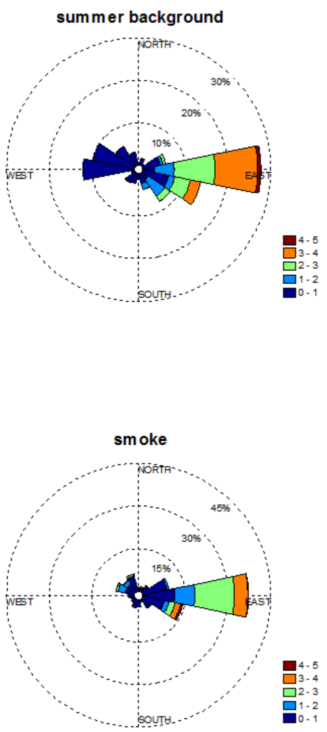
(MODIS Aqua); c) 30 June (MODIS Aqua) and d) Zoom image on 30 June (MODIS Aqua) including Burjassot site (black) and the wildfire sources at Cortes de Pallás (yellow) and Andilla (blue).

Figure 4. Time series of wind speed and direction at surface and 800 hPa (~2000 m) at the Burjassot station during the studied period.

Figure 5. All sky camera images at 7:45, 8:10 and 10:15 UTC on 29 June. The shadow band was misplaced in these two images due to an accidental offset in the internal camera clock; the saturation produced the white line in the image

Figure 6. 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).

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 22639, 2013.



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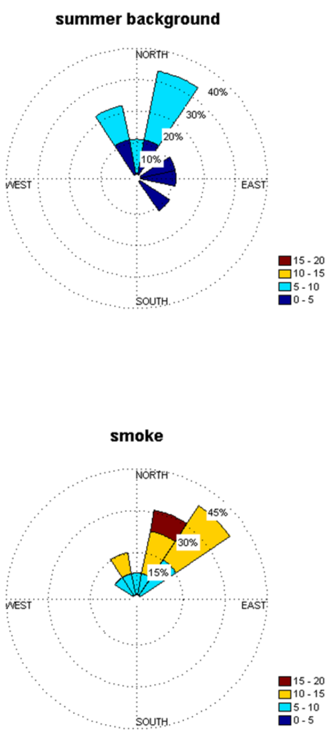


Fig. 2. Frequency diagram of wind speed and direction at 800 hPa level (~2000 m) for each aerosol period identified during the wildfire episode: a) summer background (SBG); b) dust (DDE); c) smoke(F

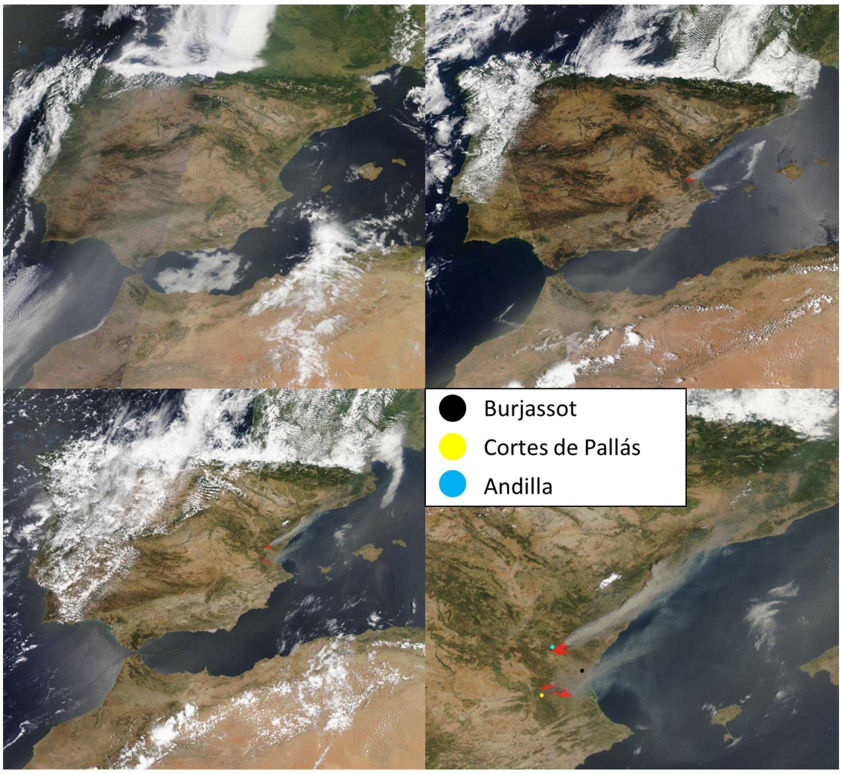


Fig. 3. Modis quick response images on: a) 28 June (MODIS Terra); b) 29 June UTC (MODIS Aqua); c) 30 June (MODIS Aqua) and d) Zoom image on 30 June (MODIS Aqua) including Burjassot site (black) and

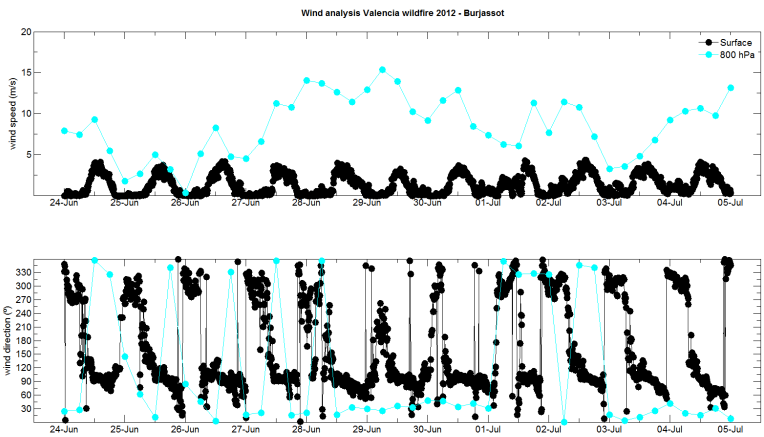
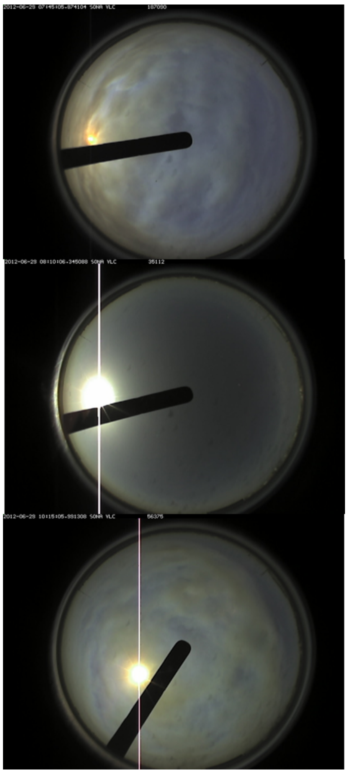


Fig. 4. Figure 4. Time series of wind speed and direction at surface and 800 hPa (∼2000 m) at the Burjassot station during the studied period.



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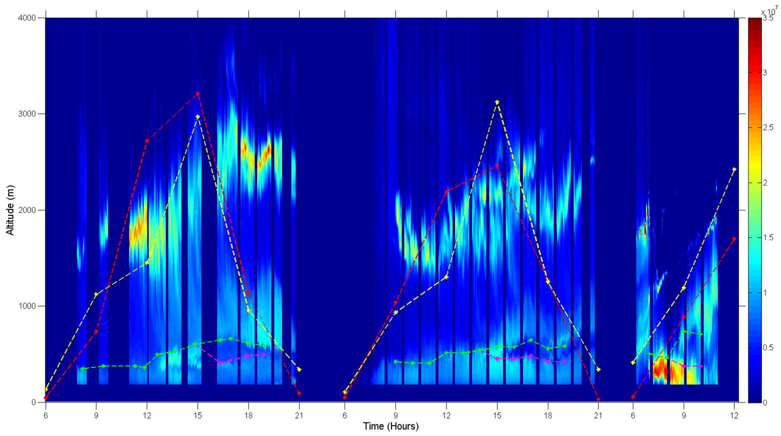

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