Synoptic Environment Associated With a Large Wildfire and a Dust Outbreak Affecting Portugal

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Introduction

In the last decades, the atmospheric models have achieved a high degree of sophistication and realism, and are powerful tools to examine the physical and dynamic mechanisms involved in the development of extreme atmospheric phenomena. The Meso-NH (Lac et al., 2018) is one of these models and it is used in the study. It is implemented with a rather complete parametrization package of sub-grid scale physical processes in the atmosphere, such as convection, cloud microphysics, cloud electricity, turbulence, surface processes, among others. In Portugal, it has been successfully used in several research fields, in particular in the understanding of fire weather conditions (Couto et al., 2020, 2021a) and dynamics of dust outbreaks (Couto et al., 2021b). However, forecasting the atmospheric conditions associated with large wildfires and dust outbreaks is still an operational problem worldwide.

The present study concentrates on the efforts to understand the meteorological environments that favour the evolution of significantly large wildfires, namely in the context of the Iberian Centre for Research and Forest Firefighting (CILIFO, www.cilifo.eu). Moreover, the main factors associated with a desert dust outbreak that occurred in the same period are also examined.

Methodology

The observations available from the Cloud-Aerosol LIdar with Orthogonal Polarization (CALIOP), a space-borne two-wavelength polarization lidar on board CALIPSO satellite are used. The CALIPSO's orbit track was identified crossing the Southern Portugal on 7th August 2018, where the Monchique wildfires burned an area of about 27000 ha. Figure 1a shows the presence of a forest fire smoke layer in southern Portugal, below 2 km altitude, and mineral dust southward extending up to the middle troposphere. Such a lidar observation was crucial for the development of the study by confirming the presence of the different types of aerosols.

Furthermore, the dust episode is also identified through the satellite observation on 2nd August 2018 (Figure 1b). The AERONET aerosol columnar properties measured at the ACTRIS Évora (38.5ºN, 7.91ºW, 293 m above sea level) confirmed the dust outbreak in early August (not shown) and helped to design the numerical experiment.

In order to explore the large mesoscale environment associated with the dust episode and the fire weather in Southern Portugal, the Meso-NH model was configured in a single domain at 10 km horizontal resolution and 270×360 grid points (Figure 1c). The vertical grid was configured with 50 stretched levels following the terrain. The simulation was initialized and forced with the European Centre for Medium-Range Weather Forecasts (ECMWF) analysis, updated every 6 hours. The physical configuration is quite similar to those used by Couto et al. (2021b), with dust emission computed using the Dust Entrainment And Deposition – DEAD model, which was incorporated in SURFEX and modified to better account for the size distribution of erodible material. On the other hand, the interactions between the wildfire and the atmosphere were not taken into account in the simulation. The experiment started on 28th July 2018 at 0000 UTC and finished at 0000 UTC on August 10, 2018.

Results and discussion

The Monchique wildfire started on 3rd August and burned up to August 10, 2018. In the first day of the episode, the model simulated air temperature values above 35ºC, relative humidity below 20 %, and wind gusts around 10 m/s (not shown), factors that favoured wildfire occurrence and propagation.

The simulation that included dust emission allowed to understand how the atmospheric dynamics affects the mobilization of Saharan dust and its transport outward from North Africa. The simulation showed that the dust observed in Évora

had origin over the Sahara Desert and was mobilized in late July. The dust transport was favoured by the circulation at around 2 km altitude from the western side of the Atlas Mountains and over the Atlantic Ocean (Figure 1c). The simulation is qualitatively in good agreement with the satellite observation (Figure 1b).

Observational and numerical approaches have been extensively used to study extreme events. Here, a wildfire event and a dust outbreak were selected and analysed thanks to the lidar observations and numerical simulations. The present study is ongoing, but already demonstrates the importance of the use of atmospheric models to complement the observations in order to better understand large scale atmospheric processes behind them. Remote sensing was used as a baseline for detecting the wildfire smoke in Southern Portugal and dust outbreak. The next steps of the study include exploring the main characteristics of the smoke and dust identified by the lidar, as well as validating the model results.

Challenges

The scientific challenges are also related to better represent this event numerically, improving the simulation, aiming to explore and understand the interactions of smoke and dust and their effects in the atmosphere.

Acknowledgements

This research was funded by the European Union through the European Regional Development Fund in the framework of the Interreg V A Spain – Portugal program (POCTEP) through the CILIFO project (Ref.: 0753_CILIFO_5_E), FIREPOCTEP project (0756_FIREPOCTEP_6_E), and also by national funds through FCT - Foundation for Science and Technology, I.P. under the PyroC.pt project (Refs. PCIF/MPG/0175/2019), ICT project (Refs. UIDB/04683/2020 and UIDP/04683/2020), and TOMAQAPA (PTDC/CTAMET/ 29678/2017).

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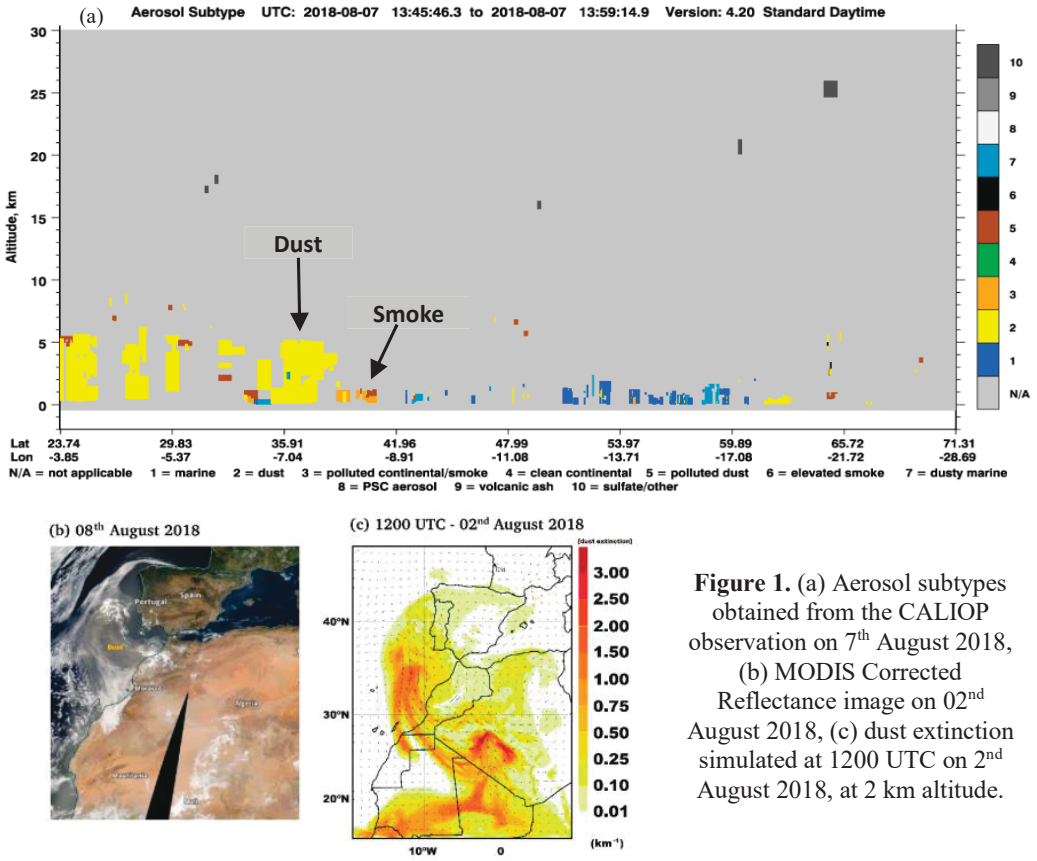

Figure 1. (a) Aerosol subtypes obtained from the CALIOP observation on 7th August 2018, (b) MODIS Corrected Reflectance image on 02nd August 2018, (c) dust extinction simulated at 1200 UTC on 2nd August 2018, at 2 km altitude.