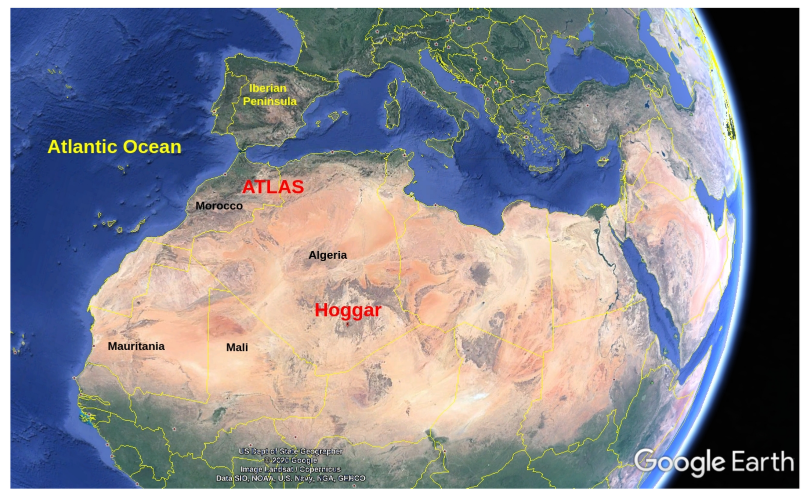
Modelling an exceptional desert dust transport toward Portugal on February 2017

Costa MJ[1,2], **Couto FT**[1*], Cardoso E[1], Salgado R[1,2], Guerrero-Rascado JL[3,4]

(1) Instituto de Ciências da Terra – ICT (Polo de Évora), Universidade de Évora, Évora, Portugal.
(2) Departamento de Física, Escola de Ciências e Tecnologia, Universidade de Évora, Évora, Portugal.
(3) Departamento de Física Aplicada, Universidad de Granada, Granada, Spain.
(4) Instituto de Investigación del Sistema Tierra en Andalucía (IISTA-CEAMA), Granada, Spain.
*E-mail: couto.ft@gmail.com

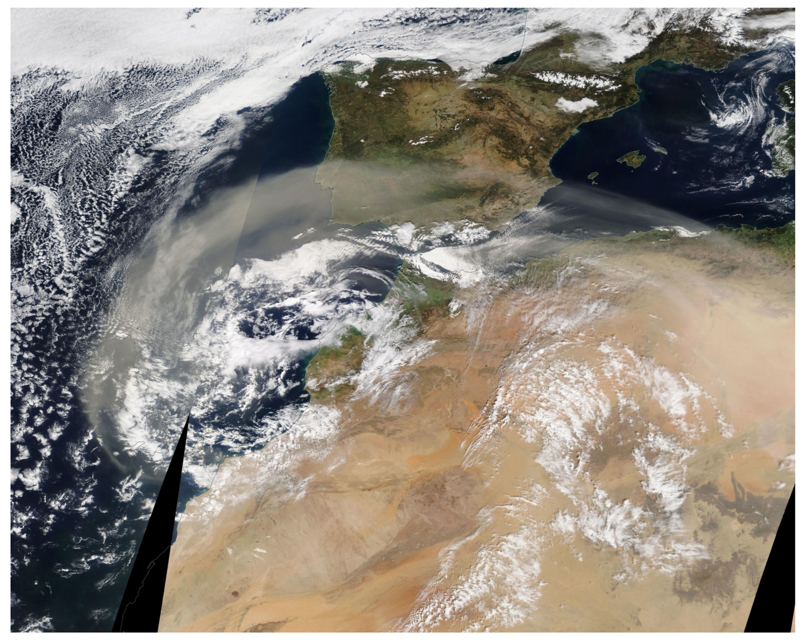
1. INTRODUCTION

The **terrain surrounding** the **Sahara desert** is formed by some mountains ranges, as the **Atlas mountain system** in northern edge of the desert and the **Hoggar Mountains** in Southern Algeria. Such orography, jointly with atmospheric circulation, plays an important role in the **mobilization** and **transport** of **desert dust** over medium and large distances.



Goal

The study explores the interaction between complex terrain and atmospheric circulation in order to **better understand** an **exceptional desert dust outbreak affecting Portugal in February 2017**.



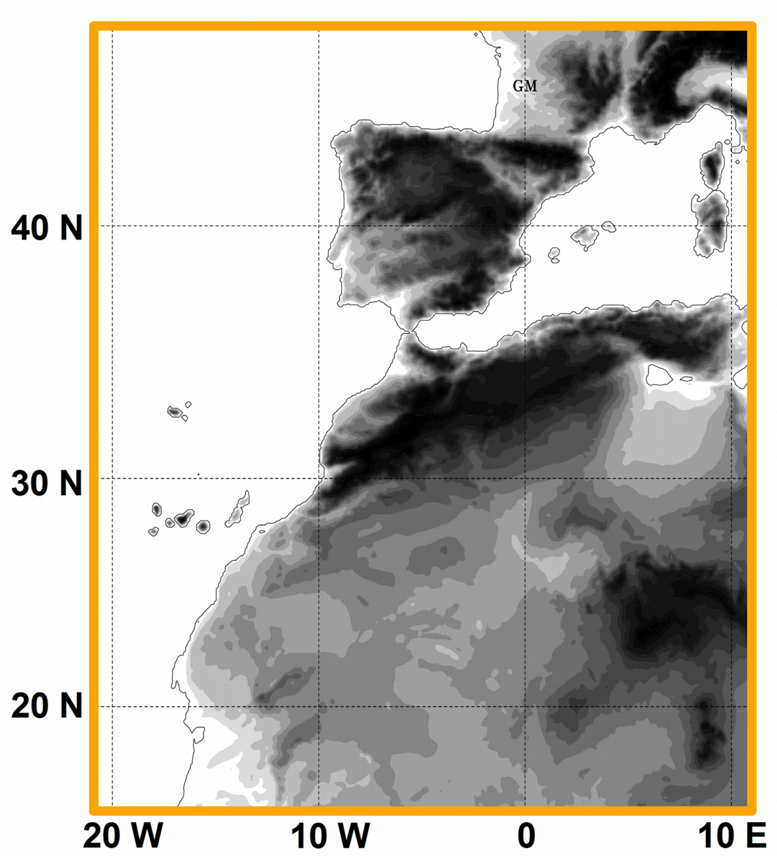
Satellite image on 21 February 2017.

2. NUMERICAL MODELLING

The **Meso-NH** model (*Lac et al., 2018*) is coupled to the externalized surface model **SURFEX** (*Masson et al., 2013*), and used in several research fields, including desert dust episodes (*Santos et al., 2013*). Here, the **ability** of the model to **simulate dust emission** is explored, as well as its **transport**. The on-line dust emission is computed inside SURFEX using the Dust Entrainment And Deposition scheme (DEAD: *Zender et al., 2003*).

Horizontal configuration

A single **large domain** with **10 km** resolution



(300x360 grid points)

Vertical configuration

50 levels

Initial conditions

The model was **initialized** from the **ECMWF Analysis** every 6h.

Physical aspects

The numerical experiments were performed using the **standard parametrization package** of **physical processes** in the atmosphere: convection, cloud microphysics, turbulence, surface processes, among others.

Period simulated

16th to 24th February 2017.

3. MODEL VALIDATION

The results from the Meso-NH **lidar simulator** (*Chaboureau et al., 2011*) are compared with the **observations** obtained from the **CALIOP**, a spaceborne two-wavelength polarization lidar on board CALIPSO satellite (*Winker et al., 2007*). The satellite orbit passing over the Sahara desert approximately at 1400 UTC on 16th February 2017 is shown in **Fig. 1a**, as well as in the model domain (**Fig. 1b**).

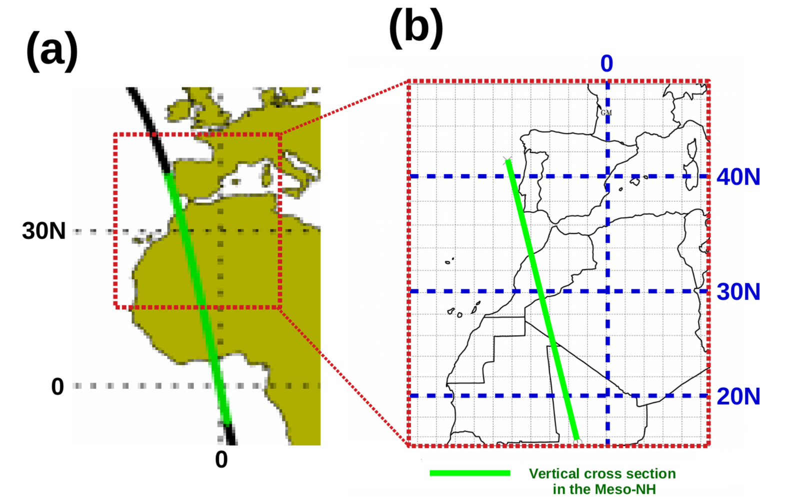


Fig. 1: (a) CALIPSO's orbit track, and (b) Meso-NH domain.

From the **CALIPSO observation**, the ATB signal at 532 nm confirms the presence of particles in the lower troposphere, namely the **dust layer southward the Atlas**, between 15ºN and 20ºN (**Fig. 2a**). The lidar simulator was able to represent the same layer structure (**Fig. 2b**). Over the ocean, around 35ºN, the model also captures the clouds around 7 km altitude. It is noteworthy the ability of the lidar product when it is compared with the dust extinction model field, which considers only the dust extinction (**Fig. 2c**).

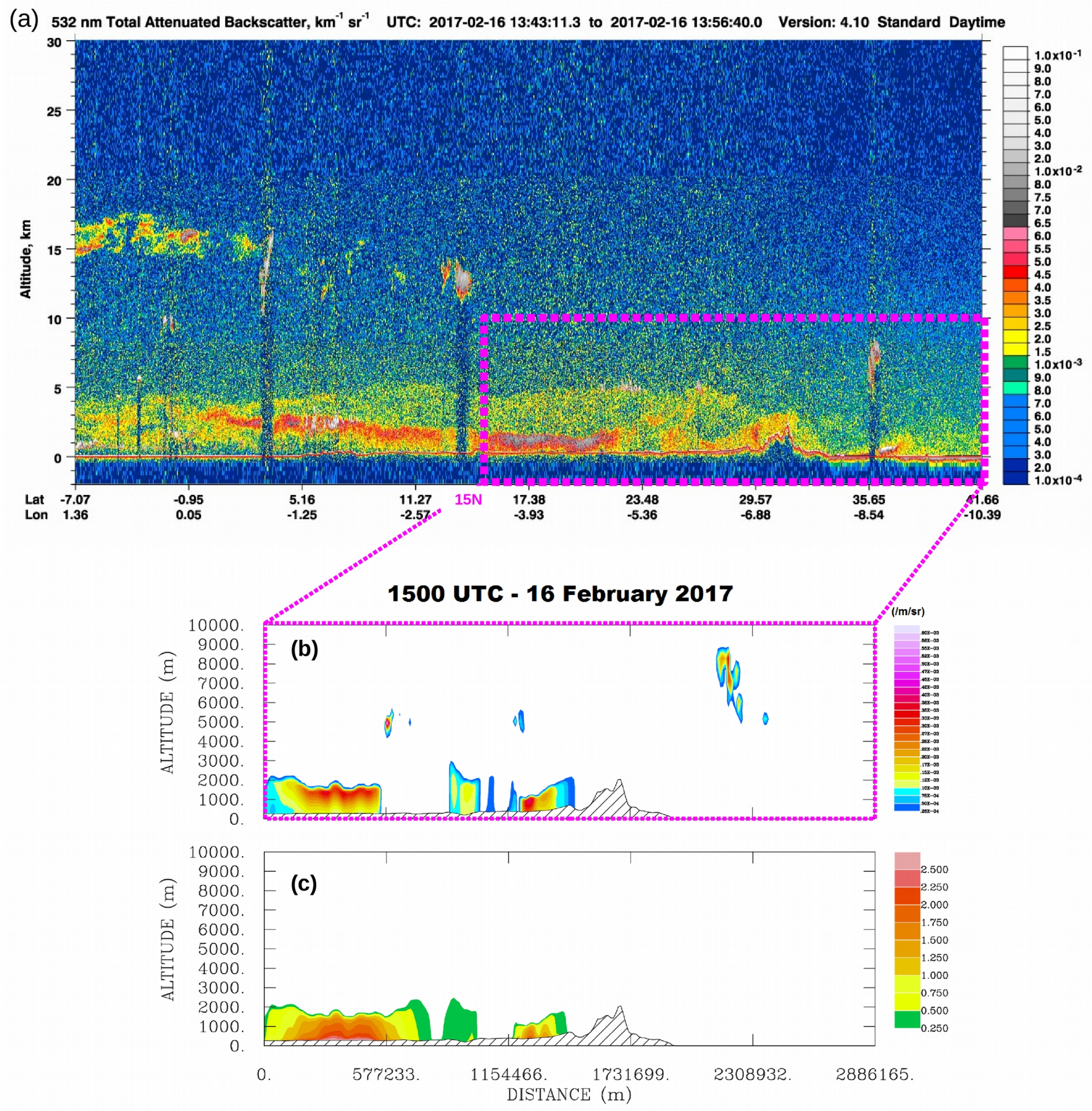


Fig. 2: Total attenuated backscattered from (a) CALIOP, (b) Meso-NH lidar simulator, and (c) Meso-NH dust extinction (km^{-1}).

This **simple comparison** is made just to verify if the **model** is able to **capture the dust**, more than quantify the amount simulated. Overall, the result indicates that the model can be used to improve the understanding about the dust outbreak event.

4. RESULTS

From the large domain and long-lasting simulation, it is possible to assess the **source of dust** and its **mobilization** several days **before** it **reach** the **Iberian Peninsula**. For example, high amount of dust may be seen at 500 m altitude in the Western Sahara desert, mainly over the Eastern Mauritania and Mali (**Fig. 3**).

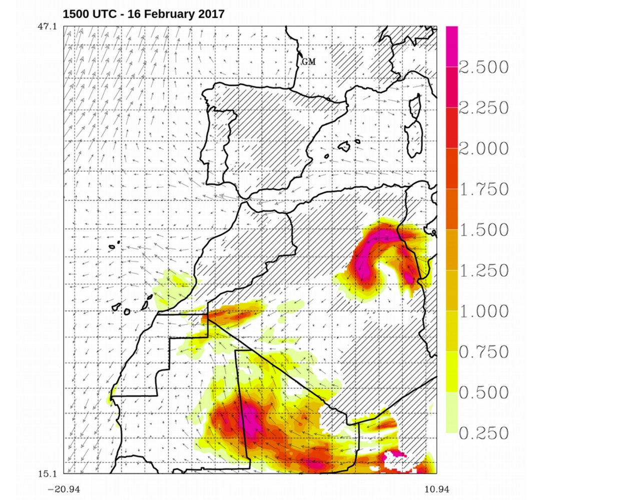


Fig. 3: Meso-NH dust extinction (km^{-1}) and wind vectors both at 500 m altitude.

In **Fig. 4a**, a **cyclonic vortex** at 1800 m altitude is identified southward the Atlas and acts as the main mechanism for **dust uplifting** up to the **free atmosphere**. The **dust uplifted** during the development of this system is **transported** in higher levels, and toward the Iberian Peninsula, by the **large scale circulation**, namely the circulation associated with a **low pressure system** centred over Morocco. This situation is showed for the dust extinction field and airflow both at 4km altitude in **Fig. 4b**.

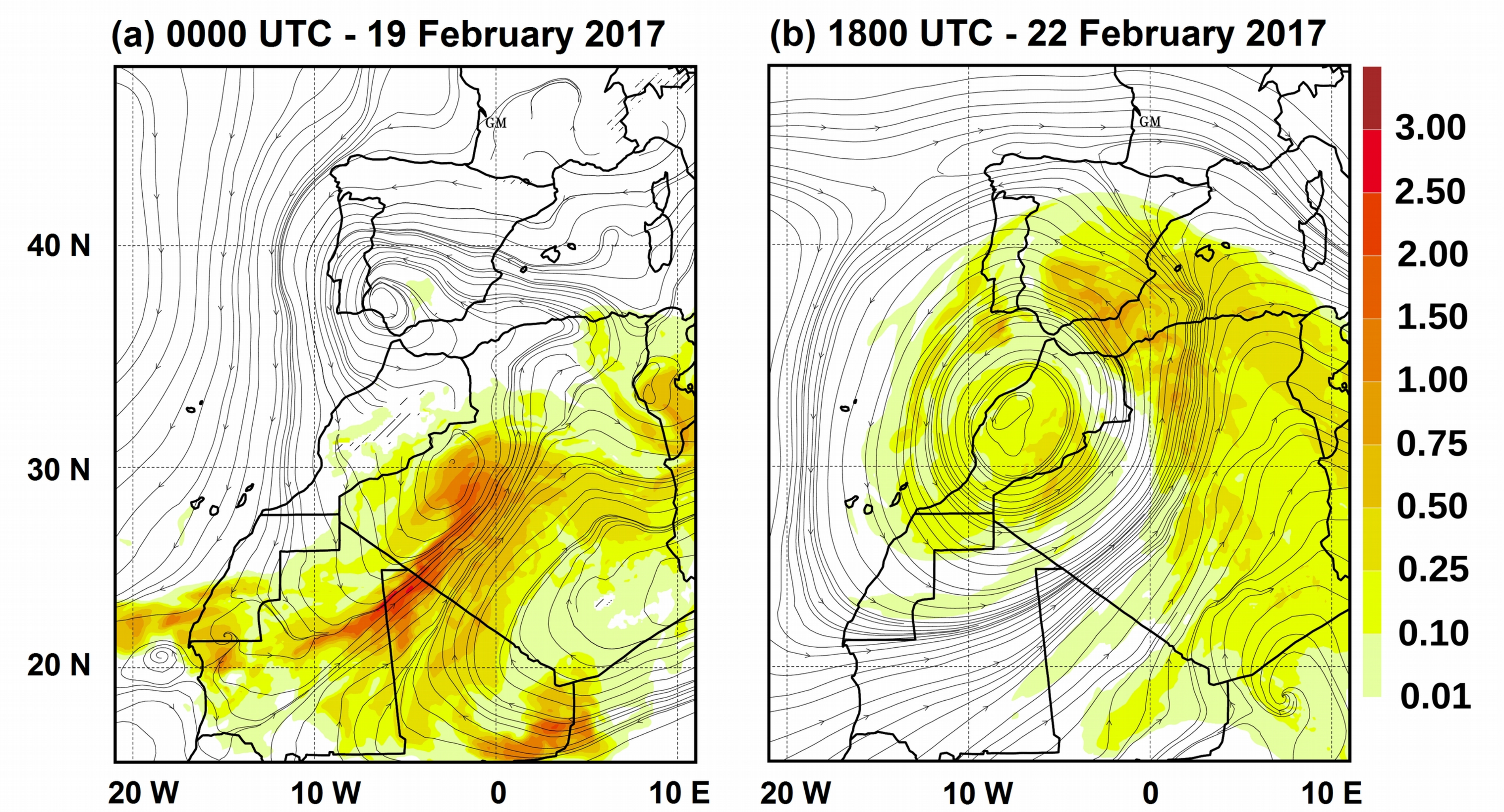


Fig. 4: Streamlines represent airflow and coloured areas dust extinction (km^{-1}) at (a) 1800 m altitude, and (b) 4 km altitude.

5. CONCLUSIONS

As expected, the simulations showed the ability to assess important details about the atmospheric circulation not resolved by low density of observations over the domain considered. Furthermore, the simulations were able to show the way that the **atmospheric ingredients** were brought together to **produce** the **exceptional transport of desert dust toward Portugal**. The **orographic effects** playing an important role in **dust mobilization** (i.e., from convergence and cyclogenesis at the surface) and **large scale circulation** to the **maintenance of the dust transport** have been highlighted. Such event were responsible for the transport of high amount of dust toward the Iberian Peninsula.

Acknowledgements

This work is co-funded by COMPETE 2020 through the ICT project (UIDB/04683/2020) with the reference POCI-01-0145-FEDER-007690 and 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).

References

- Chaboureau, J.-P., and Co-authors (2011), Q. J. R. Meteorol. Soc., 137, 236–251. https://doi.org/10.1002/qj.719.
- Lac, C., and Co-authors (2018) Geoscientific Model Development. 11, 1929-1969. https://doi.org/10.5194/gmd-11-1929-2018.
- Masson, V., and Co-authors, (2013) Geoscientific Model Development. 6, 929-960. https://doi.org/10.5194/gmd-6-929-2013.
- Santos, D., and Co-authors (2013) Atmospheric Research, 127: 178-194. https://doi.org/10.1016/j.atmosres.2012.09.024.
- Winker, D.M., Hunt, W.H., McGill, M.J. (2007) Geophys. Res. Lett., 34, L19803. https://doi.org/10.1029/2007GL030135.
- Zender, C.S., Bian, H., Newman, D. (2003) J. Geophys. Res., 108, 4416, D14. https://doi.org/10.1029/2002JD002775.