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ALTITUDE-DEPENDENT AEROSOL OPTICAL DEPTHS AND NUMBER DENSITIES AT EL TEIDE, CANARY ISLANDS

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1. Introduction

El Pico de Teide in Tenerife, Canary Islands is the third largest volcano in the world. It stands at 3,718 meters in height and is the highest peak in the Atlantic Ocean. The height and location of El Teide provides an excellent opportunity to evaluate the vertical mixing of Saharian dust transport to the Canary Islands and its contribution to the aerosol optical thickness over this region.

In the ascent to the summit you can measure the vertical aerosol structure through different levels in the troposphere. The data presented in this study provides a picture of the relative changes in tropospheric aerosol distribution that occurred in the vertical structure under the same synoptic conditions.

2. Data and Methodology

In this study we report measurements of aerosol optical thickness (AOT) and number density (ND) at Teide, Tenerife and Agaete, Gran Canaria. A Microtops II ozone-monitor sunphotometer was used to measure aerosol optical depths. The Microtops II is a hand-held multi-band sunphotometer capable of measuring the aerosol optical thickness (AOT) and direct solar irradiance in five different bands. In this study, we focus on the 870 nm aerosol band. The Climet 500 Laser Particle Counter (LPC) was used to measure the number densities at different size cuts. The CI-500 is a laser diode based aerosol particle counter that monitors particles in six size ranges: 0.3, 0.5, 1.0, 5.0, 10.0 and 25 μm.

We have also used the NOAA HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) model system to compute air parcel trajectories. We compute backward trajectories of the air masses for each of the locations studied for comparison to the ICoD model forecasts and available satellite data for the region.

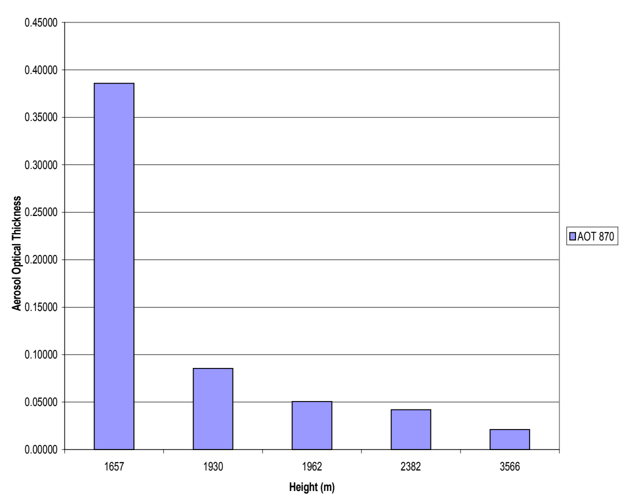
On March 23, 2003 measurements of number density and aerosol optical thickness were performed on the islands of Gran Canaria at Agaete and on Tenerife along the ascent of El Pico de Teide, from 1657 m to 3566m.

Measurements of aerosol optical thickness were obtained at five different locations/altitudes. The first measurement was taken at 1657 m above sea level at 28.166° N latitude and 16.65° W longitude. The last measurement was just below the mountain peak at 3566 m above sea level at 28.369° N latitude and 16.784° W longitude. The LPC measurements were taken at three different locations corresponding to sea level (Agaete, Gran Canaria), the base of Pico el Teide in Teide, Tenerife) at 1657 m, and near the peak at 3566 m, respectively.

3. Results

In figure 1, we observe the expected trend of a sharp decrease in the aerosol optical thickness with altitude. The aerosol optical thickness decreases an order of magnitude between the 1657 and 1930 m locations. In the 1930 m altitude we were above the lifting condensation level just above the thick cloud layer shown in picture 1. The third location was chosen because it coincided with the AQUA overpass. This measurement was obtained at an altitude of 1962 m. The 2382 m location was taken at the base of the peak before the final ascent to the peak for our last measurement location at 3566 m.

Fig. 1 Comparison of Aerosol Optical Thickness at Different Altitudes



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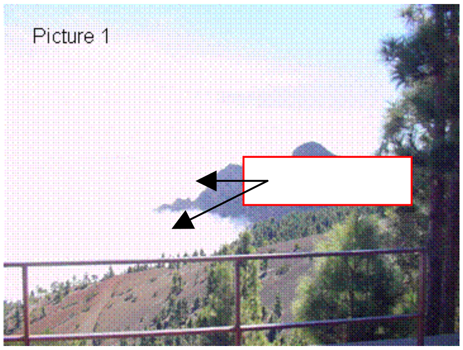


We compared aerosol optical thickness, number density and relative humidity as shown in figure 2. The aerosol optical thickness is for the 870 nm band. The number density measurement shown is for the 0.5 – 1.0 micron size fraction. The number density is expressed in μg/cm^3. The relative humidity values are shown in the secondary axis. Figure 2 shows that for the measurements taken at Teide at 1657 m and 3566 m, all three parameters decrease an order of a magnitude.

Fig 2. Aerosol Optical Thickness vs Number Density vs Relative Humidity

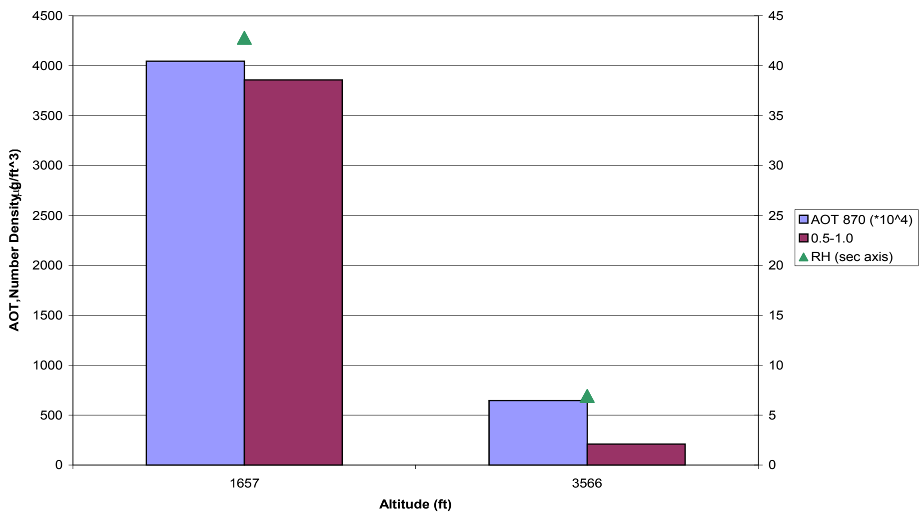
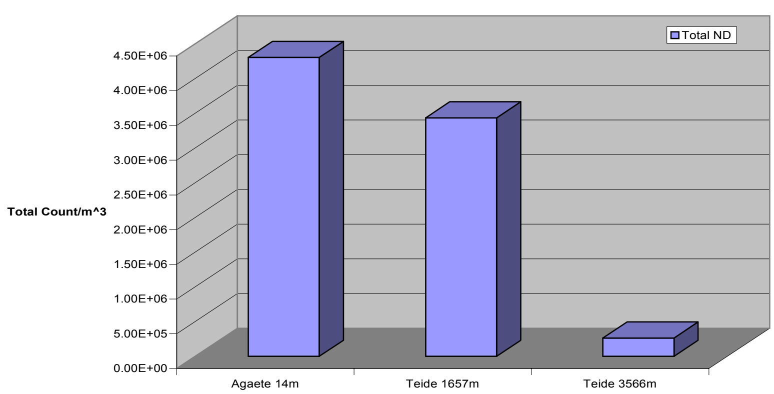


Figure 3 shows a comparison of the total number density of the measurements obtained at the two locations at El Teide with measurements taken in Puerto de las Nieves in Agaete, Gran Canary located at 28.101° N latitude and 15.713° W longitude at an altitude of 14 m. This figure shows that for these different locations at different altitudes the total number density decreases with height. Also, that this decrease is an order of magnitude between the lower altitudes and the summit.

Fig 3. Total Number Distribution for Agaete, Teide 1657 & 3566



We performed five-day back trajectories at the 1657 m location using the NOAA Hysplit model. Figures 3 shows three back trajectories performed for the 1657 m location with three different altitudes. The red, blue and green trajectory denote the path of three air masses that end at the same location at different altitudes 500 m, 1657 m, and 3000 m, respectively. As can be seen, the 1657 m (blue trajectory) and 3000 m (green trajectory) originate in the Atlantic Ocean. The 500 m (red trajectory) originates above Europe. Figure 5 shows the output of the ICoD forecast model which is a regional model that can provide information on cloud cover, dust loading and wind patterns. Using both of these models it appears that on March 20th near 12Z the air parcel following the red trajectory mixes with the Saharan dust plume and during a time when minimum cloud cover is observed in the region. Analysis of the vertical velocity profiles along the trajectory predicted by HySplit, the air parcel ending at 500-m experienced strong upward vertical velocities during its descent (red trajectory) between 21 – 23 of March. The 1657 m trajectory (blue) generally experienced strong downward vertical velocities throughout its descent during the same period. The mixing between these two air masses on March 22 – 23 could explain the higher AOT and ND values shown in Fig.1.

Fig. 4

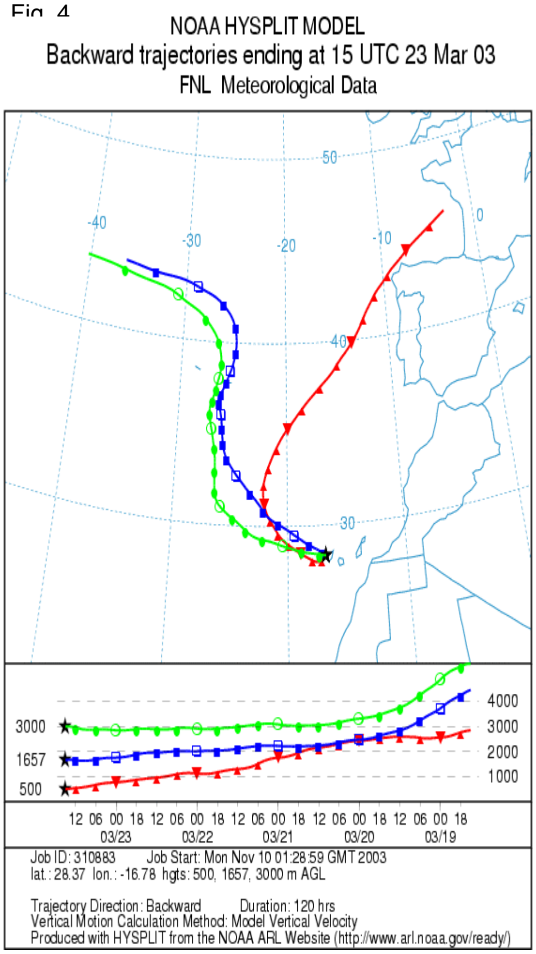


Fig. 5

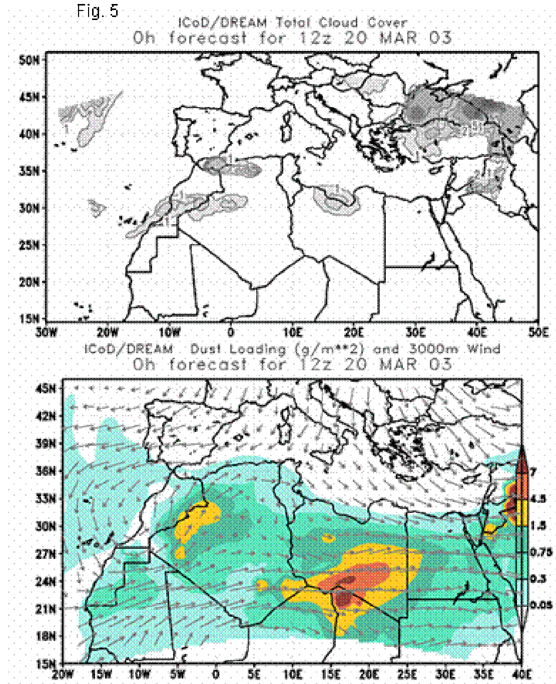


Figure 6 shows a four – day back trajectory calculated for the 3566 m location. This figure shows that the air mass present at the summit originated from the Atlantic Ocean. Figure 4 is consistent with the observations obtained at the summit, which indicate a clean, unperturbed air mass.

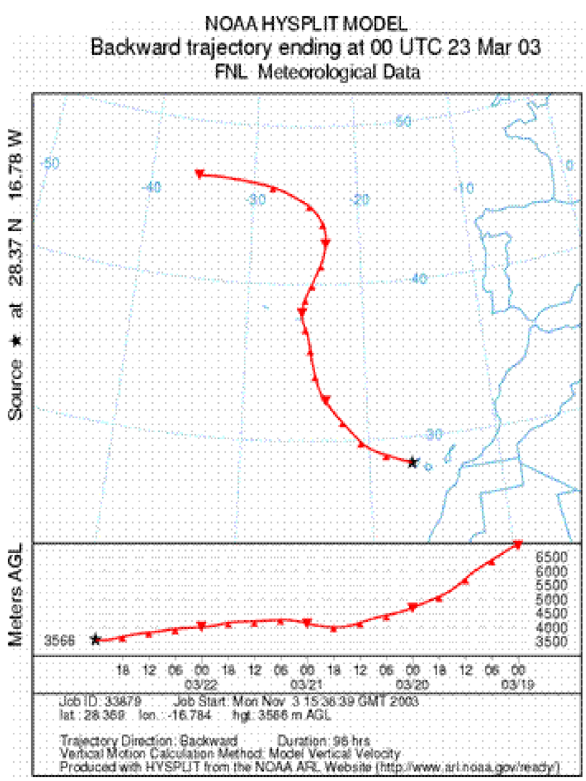
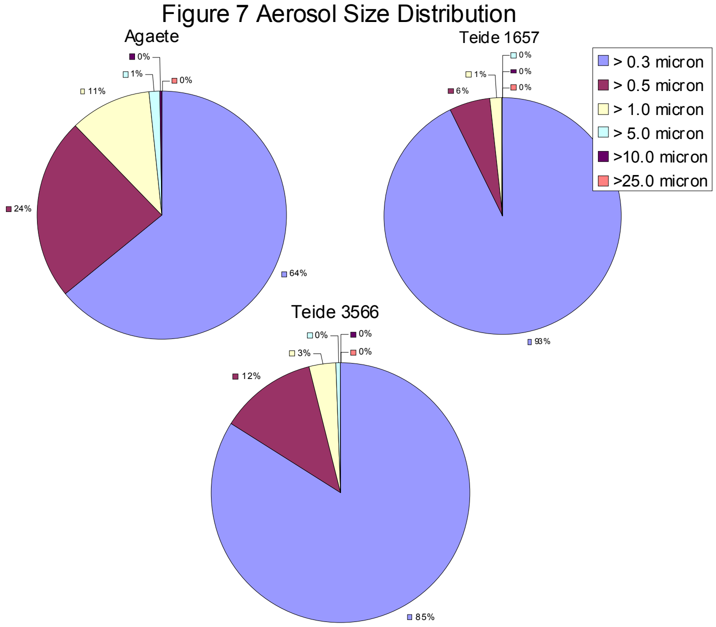


Figure 7 shows the evolution on the aerosol size distribution as a function of altitude from near sea-level through the ascent of El Teide. The 0.3 micron size fraction is dominant above the dust plume but contributes less to the total mass in the clean air above the boundary layer. The follow-on experiment during March 2004 will allow us to layer the elemental composition and on top of these data.

Figure 7 Aerosol Size Distribution



4. Acknowledgements

This research was funded by the NOAA Center for Atmospheric Sciences (NCAS) at Howard University under the Educational Partnership Program and by the Center of Terrestrial and Extraterrestrial Atmospheres (CSTEA) at Howard University under NASA grant number NCC5 – 184. The authors would like to thank Drs. Roy Armstrong and Yasmin Detrés from the University of Puerto Rico at Mayagüez for the use of their portable Microtops II sunphotometer. We would also like to thank the Instituto de Ciencias Marinas de Gran Canaria scientists for their generous assistance, collegiality and hospitality.

5 References

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