Observational evidence for long-range transport of bioaerosols by African dust

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INTRODUCTION

Bioaerosols might be some of the most understudied and puzzling environmental particles when it comes to our understanding of their impact on weather and climate. More research has been focused on their health impacts than on how they impact cloud and precipitation formation (Kim et al., 2018). Some studies suggest that bioaerosols are not just a local phenomenon but, in fact, can be transported over thousands of kilometers by deep convection, tropical waves and on dust from African windstorms.

In this study, measurements of fluorescing aerosol particles (FAP) with the Wideband Integrated Bioaerosol Sensor (WIBS) have been conducted in Puerto Rico and Spain during African dust intrusions. The primary objectives of the analysis that is currently in progress are:

- Comparison of bioaerosol in African dust plumes aged over widely different time scales – 3 days (Spanish intrusion) vs 10 days (Puerto Rican intrusion).
- Comparison of bioaerosols in African dust layers passing over different surfaces – land vs marine.
- Comparison of African dust bioaerosol characteristics – FAP type number concentration, fraction of total particles, fluorescent intensity, size and shape.
- Comparison of African dust non-FAP characteristics – number and volume concentration, size and shape.
- Comparison of air mass histories – RH, mixing depth, temperature and precipitation.

WIBS-NEO INSTRUMENT

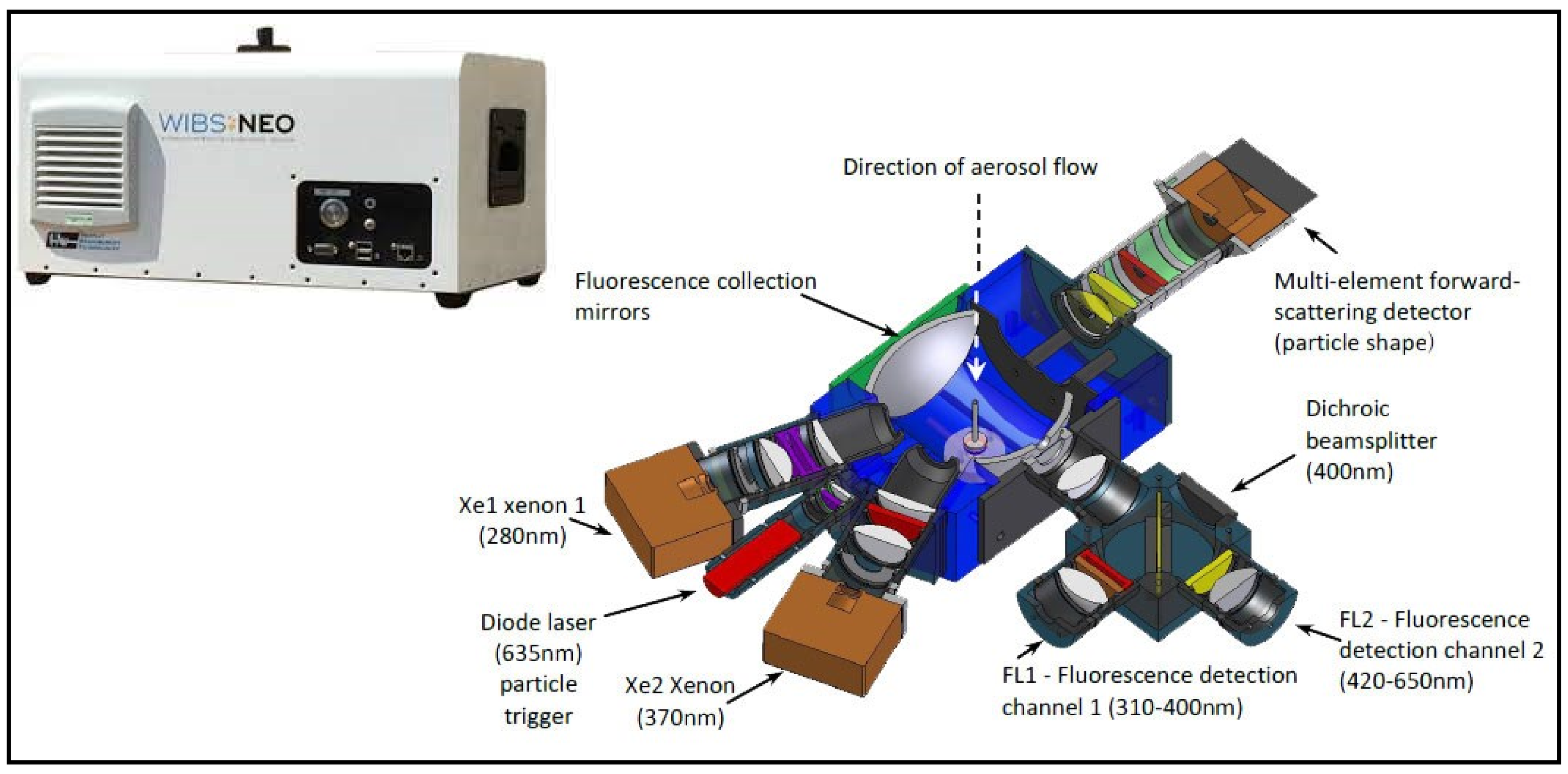

Figure 3. The Wideband Integrated Bioaerosol Spectrometer (WIBS) measures single particle light scattering and fluorescence. Particles are introduced to the WIBS via an inlet that directs them through a 653 nm wavelength laser beam where their side-scattered light is collected and converted to an equivalent optical diameter (EOD). The forward-scattered light illuminates a quad-detector whose output is used to derive an asphericity factor (AF). The scattered light signal activate xenon lamps that fire sequentially. The first lamp is filtered at 280 nm illumination, the second at 370 nm. If a particle is composed of material that autofluoresces when illuminated at either of these wavelength, photomultiplier tubes (PMT), filtered at bandwidths of 310-400 nm and 420-650 nm detect light that is emitted at these wavelengths. These detection wavebands have been selected to optimize detection of common bioaerosol components such as tryptophan and nicotinamide adenine di-nucleotide (NADH). The derived EODs are from 0.5 to 30 µm.

TEMPORAL EVOLUTION

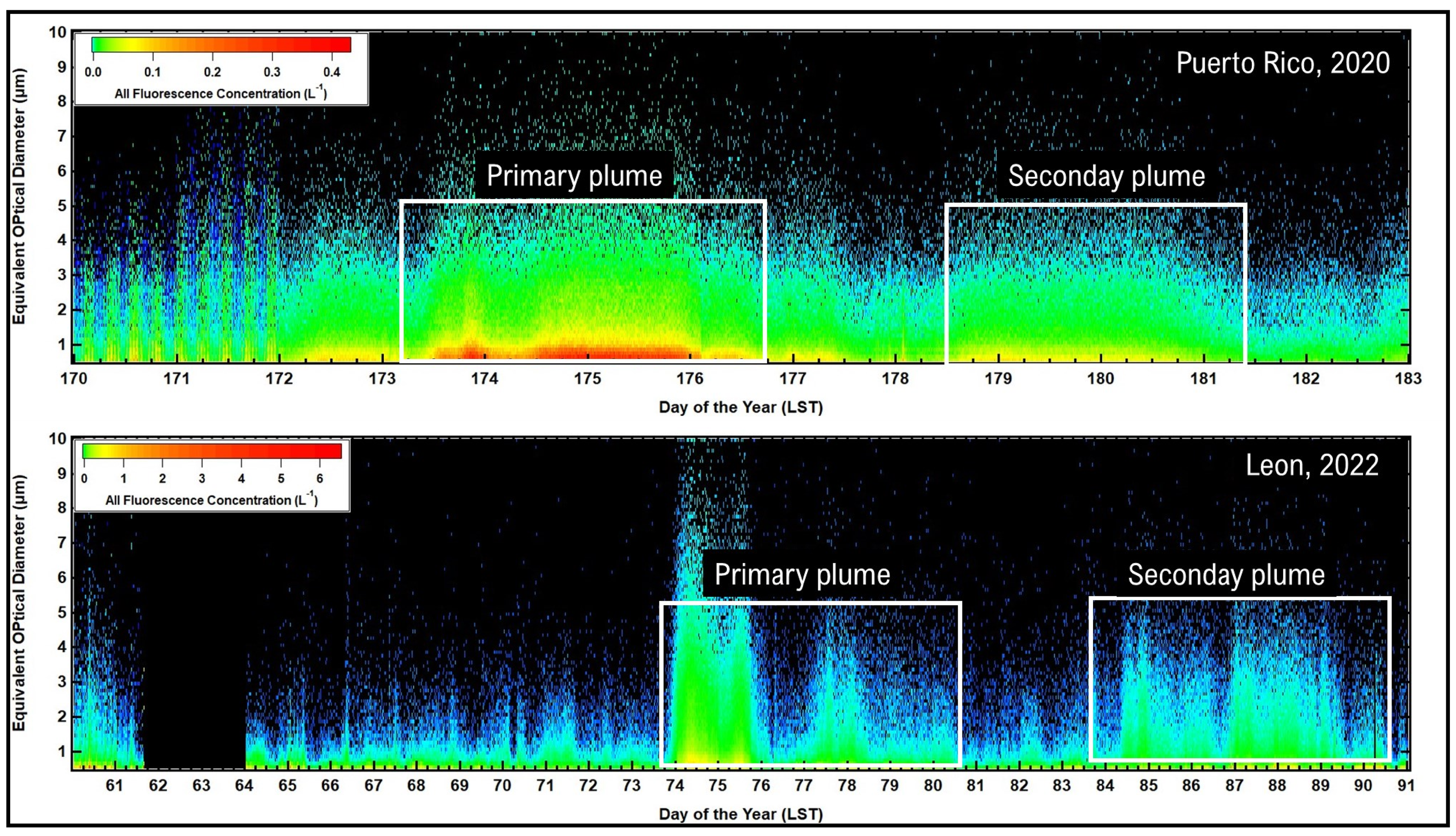

Figure 4. The FAP number concentrations increase by an order of magnitude during the first and second dust events in Puerto Rico during June, 2020 (upper panel) and in Spain during March, 2022. During these events the particles are also much larger (< 3 µm under normal conditions and > 5 µm during the dust events).

AFRICAN DUST INTRUSIONS

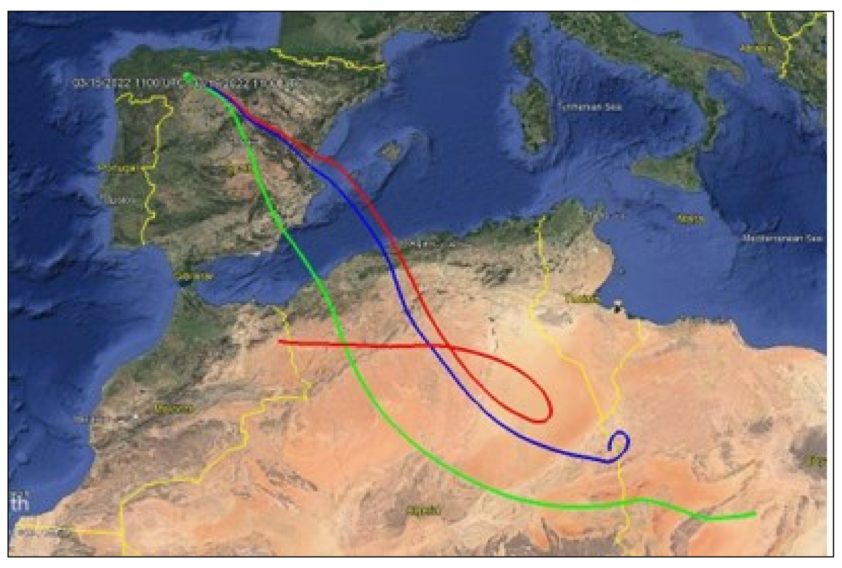

Figure 1 (left). During March 2022 plumes of African dust passed over Leon, Spain where the dust properties were measured with the WIBS. The Hysplit back trajectories shown here are 24-hour air mass histories ending at 50 (green), 100 (blue) and 300 m (red) on March 25th. The origins are mostly from northern Africa.

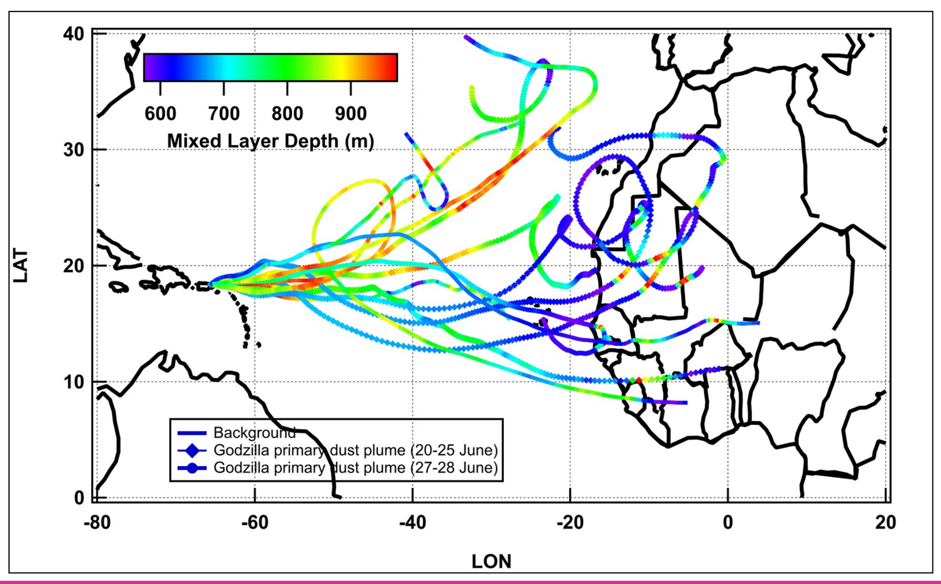

Figure 2 (right). During June 2020 several plumes of African dust passed over Puerto Rico where the dust properties were measured with the WIBS. The Hysplit back trajectories shown here are 240-hour air mass histories color coded by mixing depth. The origins are mostly from western Africa.

TEMPORAL EVOLUTION (continued)

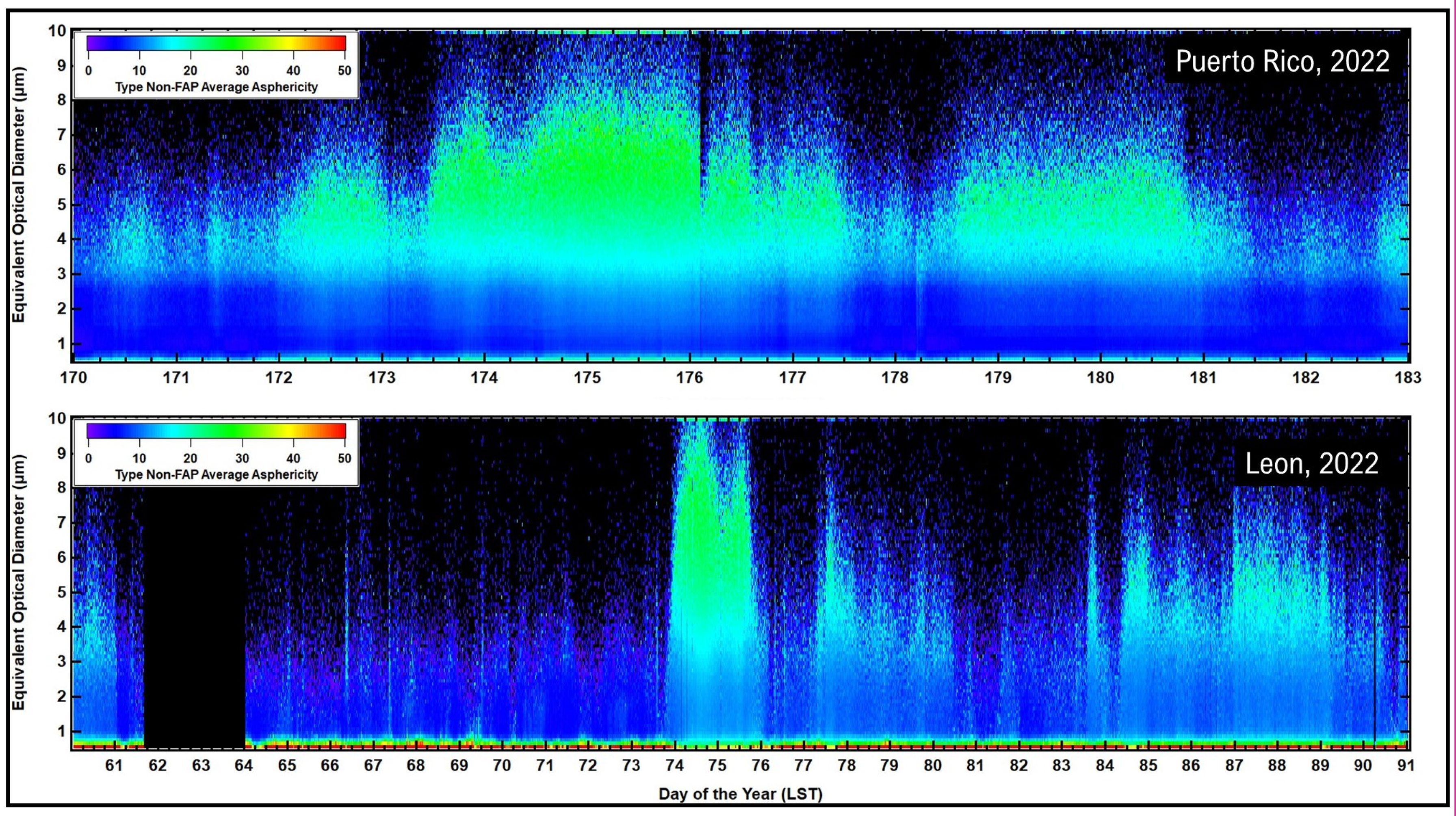

Figure 5. The dust particle intrusions are clearly identified by their asphericity shown here for the Puerto Rico dust event (top panel) and Leon event (bottom panel). Values of the asphericity are normalized to a range of 0-100, where asphericities < 20 signify spherical particles and larger values are associated with non-spherical particles.

FREQUENCY DISTRIBUTIONS

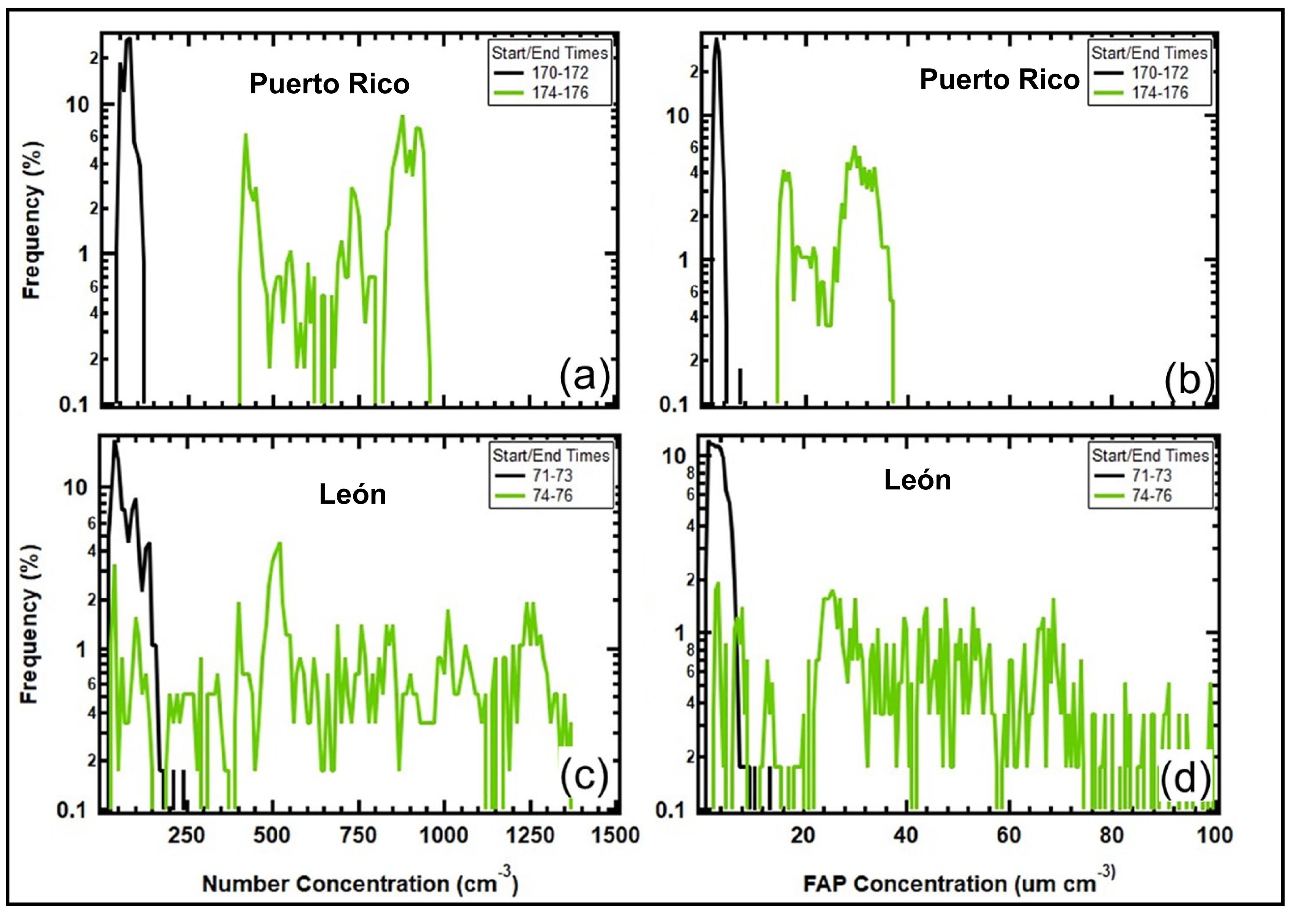

Figure 6. The total and FAP number concentrations are clearly much higher in the dust (green) than under normal conditions (black). The dust events in Puerto Rico (panels a,b) have much narrower distributions (10 days aging) while in León (panels c,d) they cover a much broader range of concentrations (24 hours of aging).

ONGOING ANALYSIS

- Comparison of FAP types between Puerto Rico and León events.
- Evaluation of size distribution differences.
- Analysis of ground cover composition at dust origins.
- Identification of FAP feature unique to the Puerto Rico vs León events.

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REFERENCES: Kim et al. (2018). *J Environ Sci*, 67, 23–35.