Methodologies for the Monitoring and Caracterization of Bioaerosols: the role of lake emissions to atmosphere

Célia M. Antunes

ICT, IIFA & DQUI, ECT

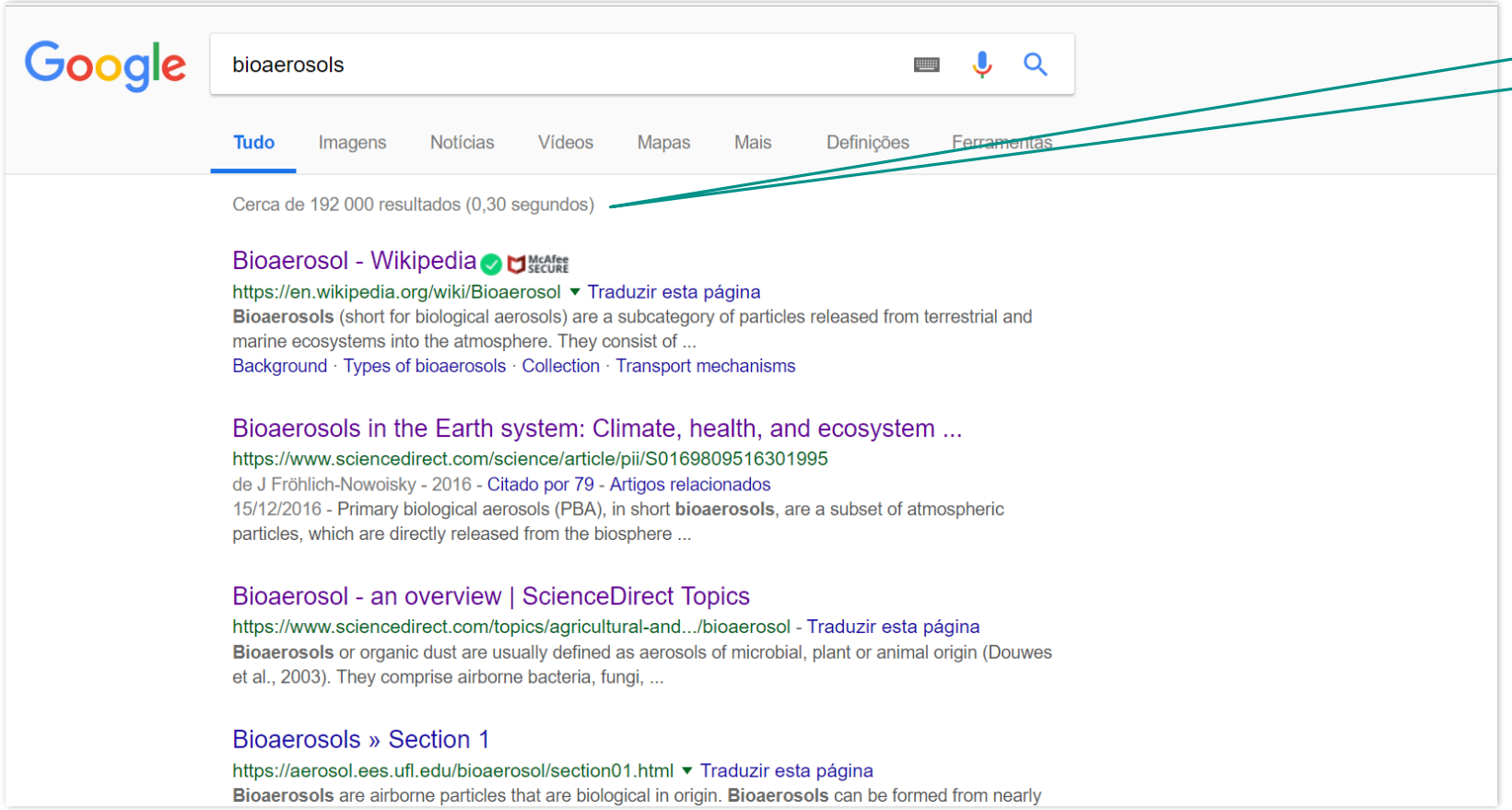
ICT

UNIVERSIDADE DE ÉVORA
ESCOLA DE CIÊNCIAS E TECNOLOGIA

Bioaerosols…

- Bioaerosols: background and definitions
- Types of Bioaerosols
- Transport mechanisms
- Biogeochemical and health impacts
- Sampling methods
- Characterization of bioaerosols
- Future developments

Bioaerosols



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Bioaerosols – hot topic

International Journal of Hygiene and Environmental Health 218 (2015) 577–589

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International Journal of Hygiene and Environmental Health

journal homepage: www.elsevier.com/locate/ijheh

Review

Evaluation of exposure–response relationships for health effects of microbial bioaerosols – A systematic review

Sandra M. Walser[a,*], Doris G. Gerstner[a], Bernhard Brenner[a], Jürgen Bünger[b], Thomas Eikmann[c], Barbara Janssen[a], Stefanie Kolb[a], Annette Kolk[d], Dennis Nowak[e], Monika Raulf[b], Helmut Sagunski[f], Nadja Sedlmaier[g], Roland Suchenwirth[h], Gerhard Wiesmüller[i], Klaus-Michael Wollin[h], Irene Tesseraux[j], Caroline F.W. Herr[a]

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JES JOURNAL OF ENVIRONMENTAL SCIENCES www.jesc.ac.cn

Review

Molecular approaches for the detection and monitoring of microbial communities in bioaerosols: A review

Keunje Yoo[1,5], Tae Kwon Lee[2], Eun Joo Choi[3], Jihoon Yang[5], Sudheer Kumar Shukla[4], Sang-il Hwang[5], Joonhong Park[1,]*

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ABSTRACT

Bioaerosols significantly affect atmospheric processes while they undergo long-range vertical and horizontal transport and influence atmospheric chemistry and physics and

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Atmospheric Research

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Invited review article

Bioaerosols in the Earth system: Climate, health, and ecosystem interactions

Janine Fröhlich-Nowoisky [a,*], Christopher J. Kampf [a,b], Bettina Weber [a], J. Alex Huffman [c], Christopher Pöhlker [a], Meinrat O. Andreae [a], Naama Lang-Yona [a], Susannah M. Burrows [d], Sachin S. Gunthe [e], Wolfgang Elbert [a], Hang Su [a], Peter Hoor [f], Eckhard Thines [g], Thorsten Hoffmann [b], Viviane R. Després [h], Ulrich Pöschl [a,*]

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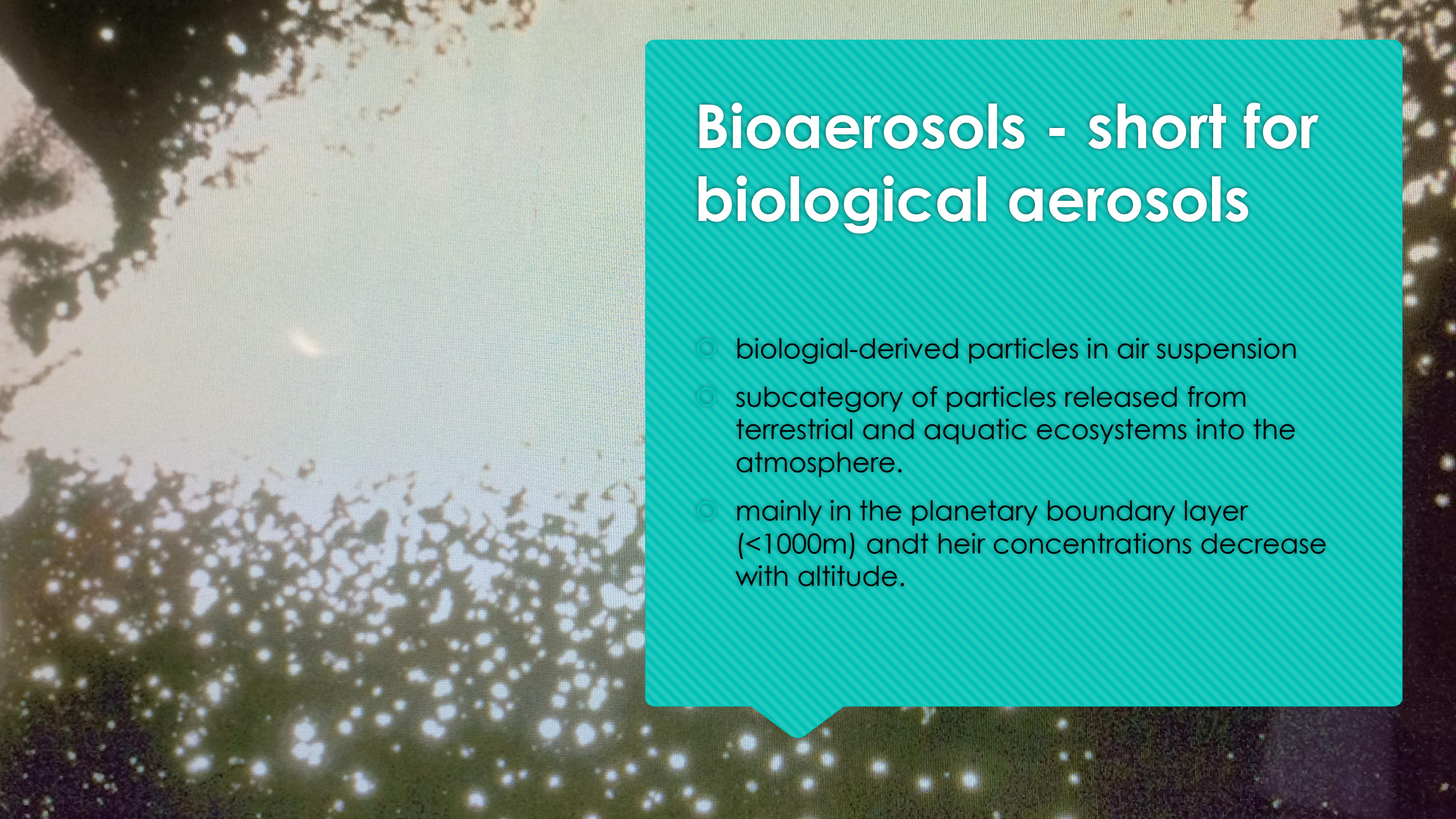
ABSTRACT

Aerosols of biological origin play a vital role in the Earth system, particularly in the interactions between atmosphere, biosphere, climate, and public health. Airborne bacteria, fungal spores, pollen, and other bioparticles are essential for the reproduction and spread of organisms across various ecosystems, and they can cause or enhance human, animal, and plant diseases. Moreover, they can serve as nuclei for cloud droplets, ice crystals, and precipitation, thus influencing the hydrological cycle and climate. The sources, abundance, composition, and effects of biological aerosols and the atmospheric microbiome are, however, not yet well characterized and constitute a large gap in the scientific understanding of the interaction and co-evolution of life and climate in the Earth system. This review presents an overview of the state of bioaerosol research, highlights recent advances,

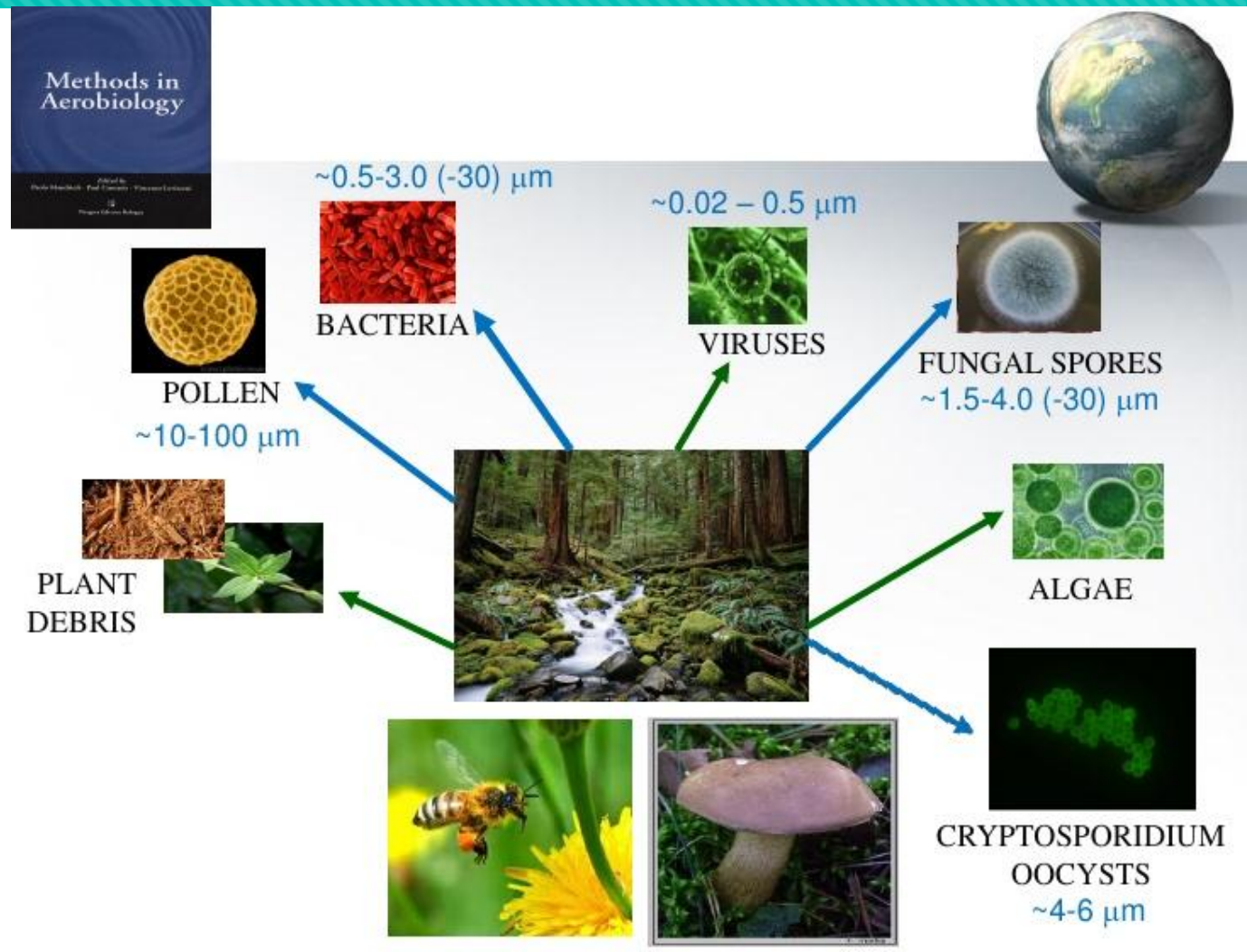


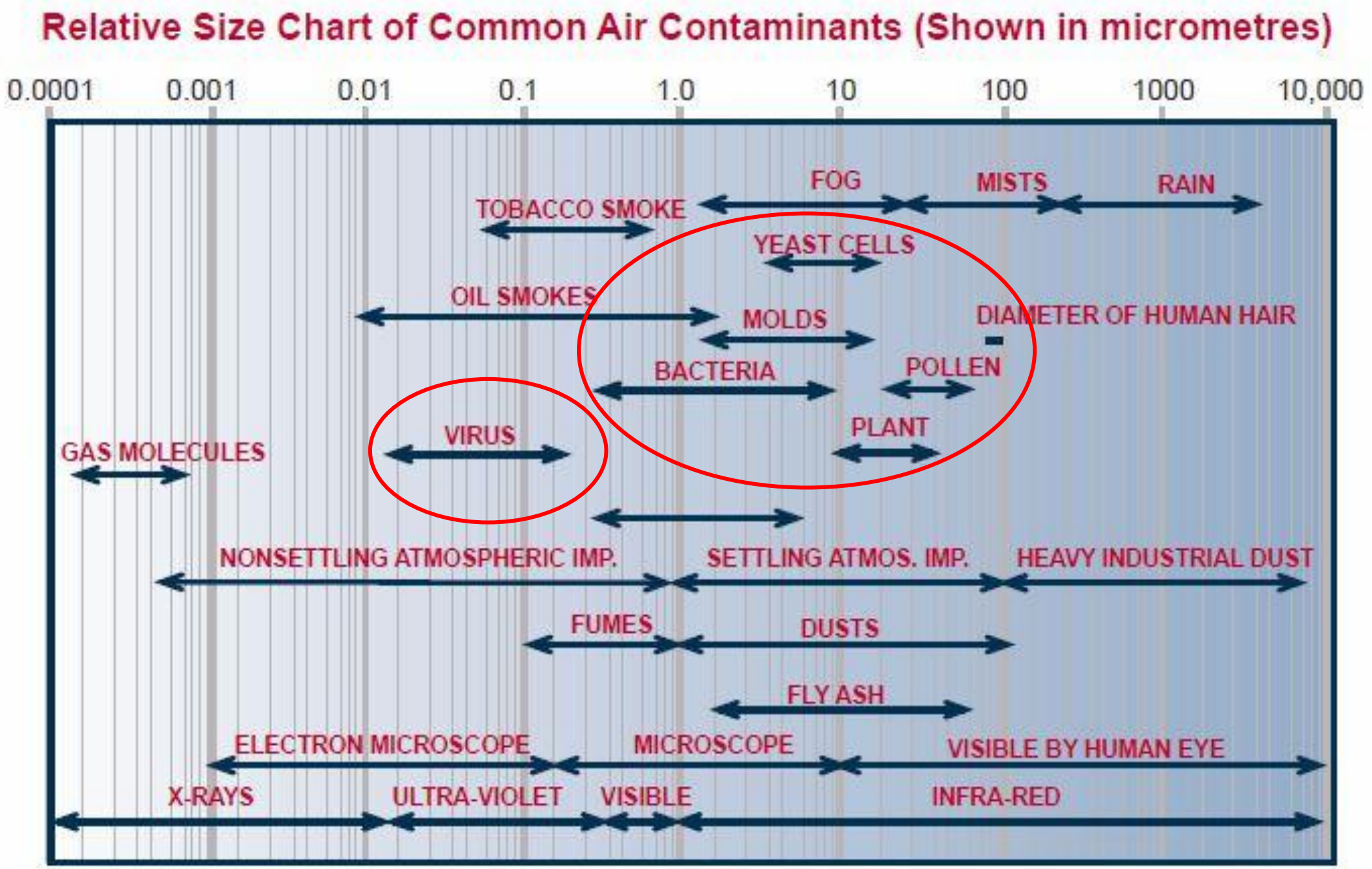
Bioaerosols - short for biological aerosols

- biologial-derived particles in air suspension
- subcategory of particles released from terrestrial and aquatic ecosystems into the atmosphere.
- mainly in the planetary boundary layer (<1000m) andt heir concentrations decrease with altitude.

Bioaerosols – *Who/What* are they?

- consist of both **living** and **non-living** components
  - Organisms such as bacteria, yeast, mold and other fungi
  - dispersal methods of the organisms: spores and pollen
  - Biological excretions
  - Debris: human and animal skin cells, animal dander, plant or fungi parts
  - viruses

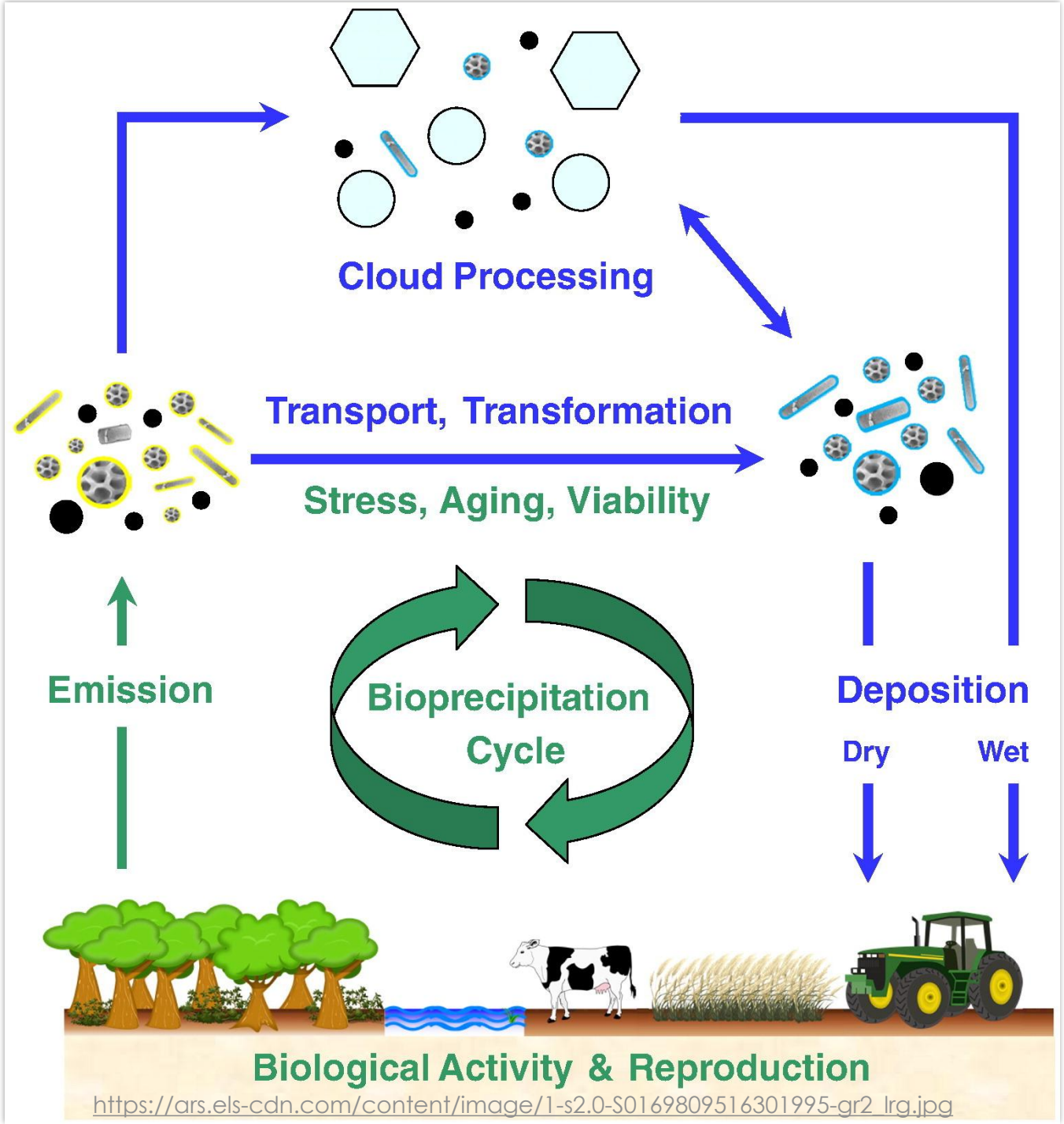




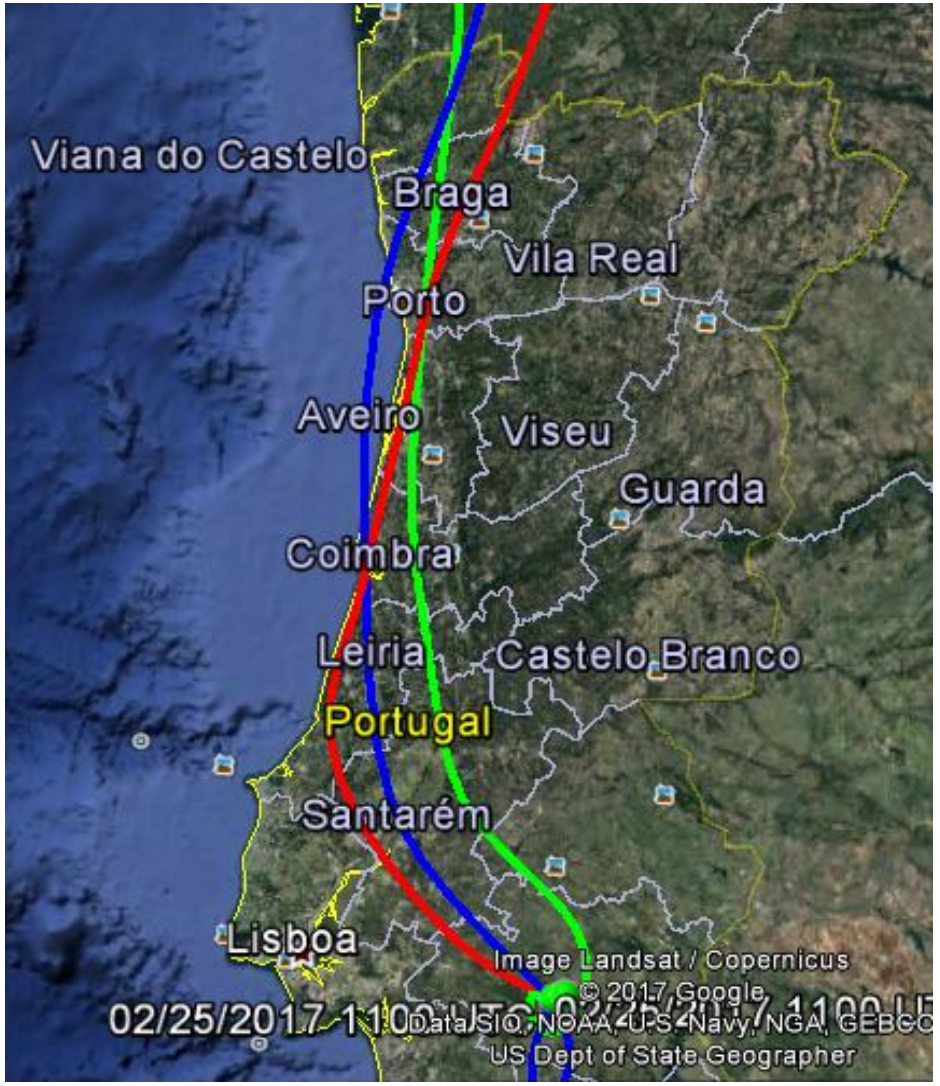
http://www.spacefilters.com.au/wp-content/uploads/2012/07/12.jpg

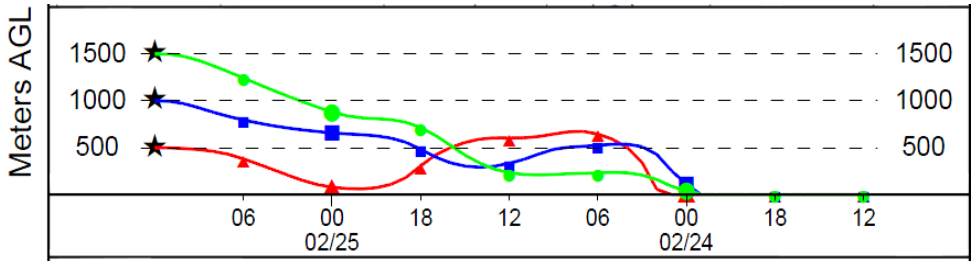
Bioaerosols composition depends on emission and transport

- over water environments primarily consist of bacteria, and algeae, cyanobacteria
- over terrestrial environments are rich in bacteria, fungi and pollen.



- Ejection of bioaerosols into the atmosphere
- Transported by air masses
  - Small scale transport via clouds
  - Large scale transport via dust plumes
- Community dispersal – dependent on meteorological conditions



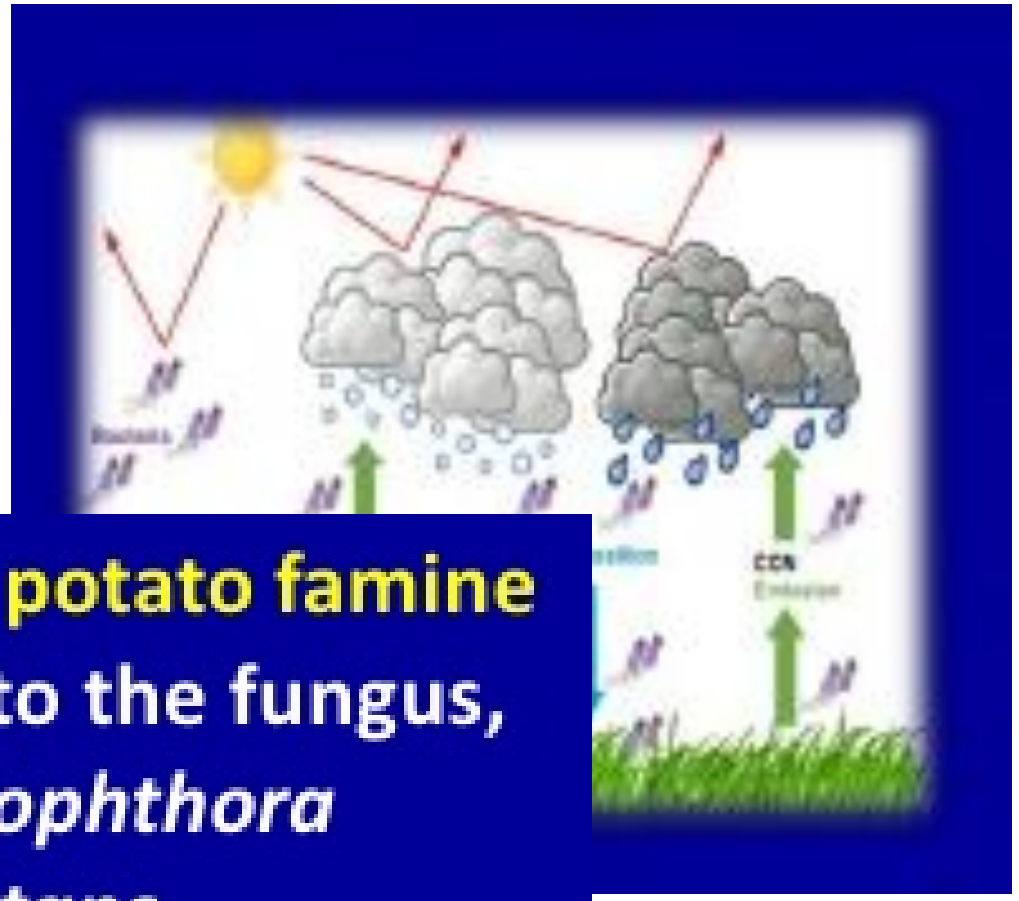


Pollen can fly for hundreds of Km in air masses!!

It may change during the transport!

Monitoring bioaerosols? Why?

- Biogeochemical impacts
  - Climate - Impact on cloud formation acting as **ice nuclei**
- Environmental health impacts and wellfare
  - Fungal infection of crops



Irish potato famine due to the fungus, *Phytophthora infestans*

Monitoring bioaerosols? Why?

- Because Bioaerosols greatly account for the QUALITY of the AIR that WE in CONTACT WITH and that WE BREATH

WAO white book, 2013

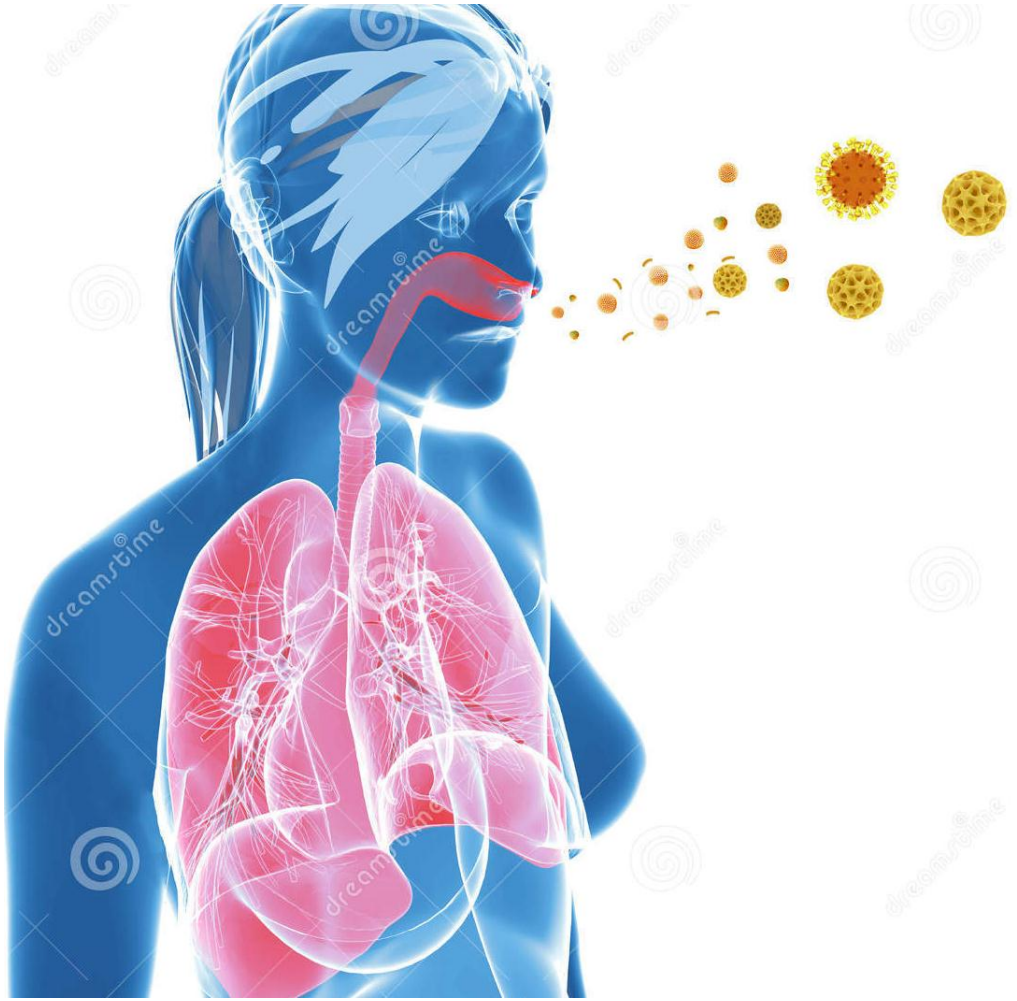
Monitoring bioaerosols? Why?

Unknown Inhaled substances at unknown doses

Morbidity

Disease

DEATH!!



The AIR we BREATH...

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Airborne bioaerosols and their impact on human health

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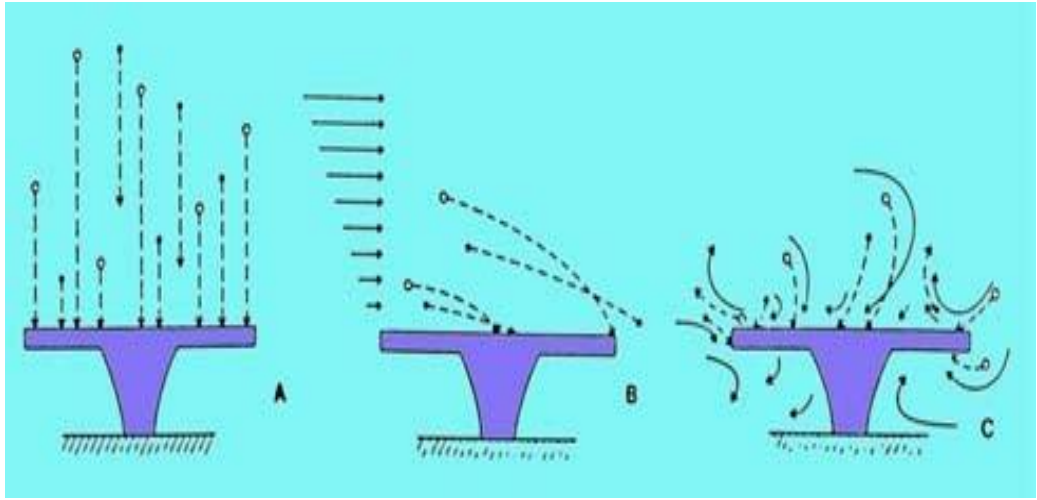
Contents

Methods for bioaerosol sampling

Métodos de amostragem astrobiológica			
	Principio físico	**Modo de amostragem**	**Captadores**
Gravimétricos	Amostradores de precipitação	Precipitação gravimétrica	Placas de Petri Captador Durham Captador Tauber
		Precipitação eletrostática	
		Precipitação térmica	
Volumétricos	Amostradores de Impacto	Impacto por sucção	Captador Hirst
		Impacto em cascata	Captador Andersen Captador ChemVol
		Ciclónico	Captador Ciclónico
		Inercia	Captador Rotorod
	Amostradores de filtração	Meio sólido	Filtros de fibra Captador Cour Filtros de membrana Filtros em cassetes
		Meio liquido	Captador Mcleod AGI
	AUTOMATED SYSTEMS – image recognition; specific fluorescence		

Methods for bioaerosol sampling: Gravimetric methods

Deposicion by gravitacional forces:



- Passive collection
- Does not allow to determine concentration
- Very good to evaluate viability of the bioaerosols

Gravimetric samplers

- Slides / Petri dishes
- Durham method
- Tauber traps

Durham samplers

Catalunya (1983-1988)

Wind wing

Tauber Traps

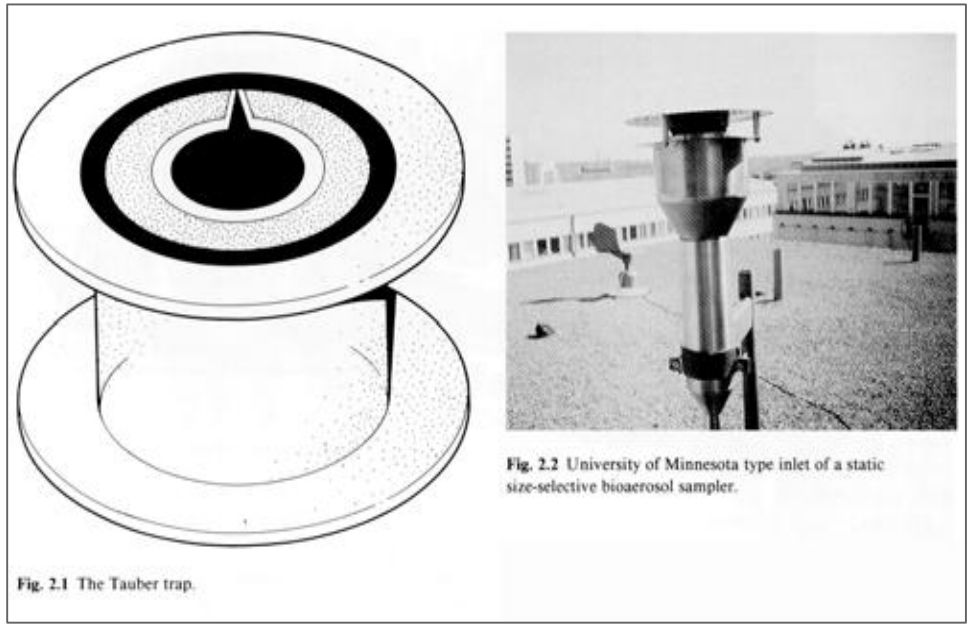


Fig. 2.1 The Tauber trap.

Fig. 2.2 University of Minnesota type inlet of a static size-selective bioaerosol sampler.

Methods for bioaerosol sampling

Impact by Suction

- Single-stage impactors
- Cascade impactors
- Cyclones
- Impingers
- Electrostatic precipitators
- Filters

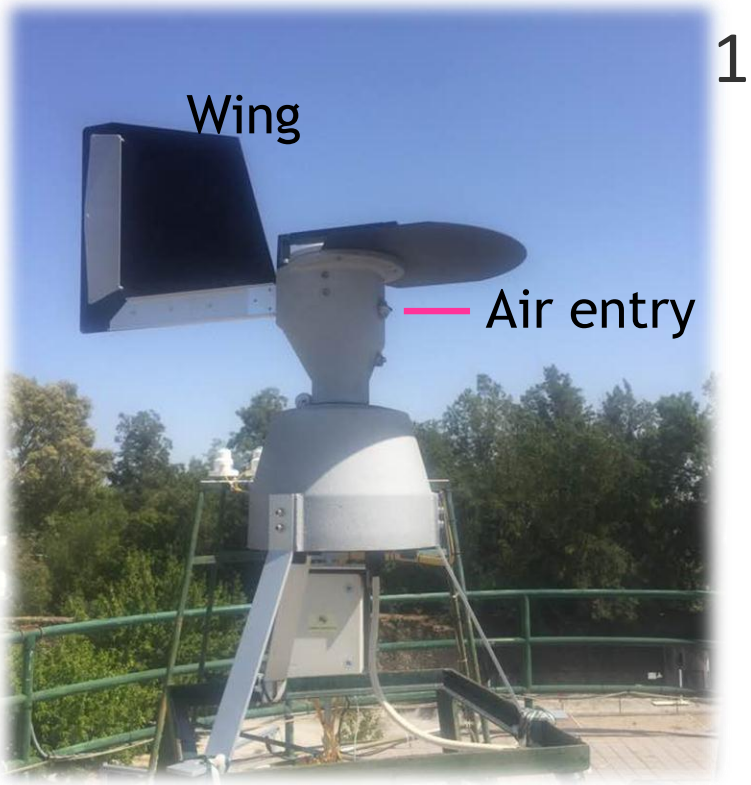
VOLUMETRIC METHODS

Methods for bioaerosol capture: Volumetric methods

Volume of sampled air is known

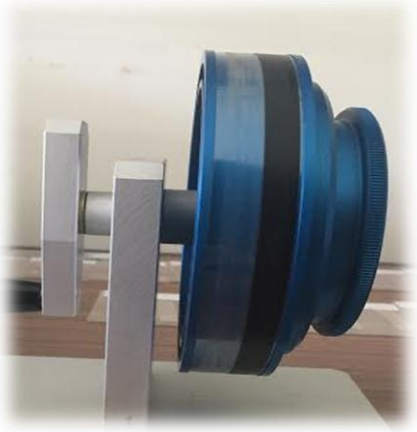
Allows determination of airborn bioaerosols concentration

Hirts type pollen and spore trap – single stage



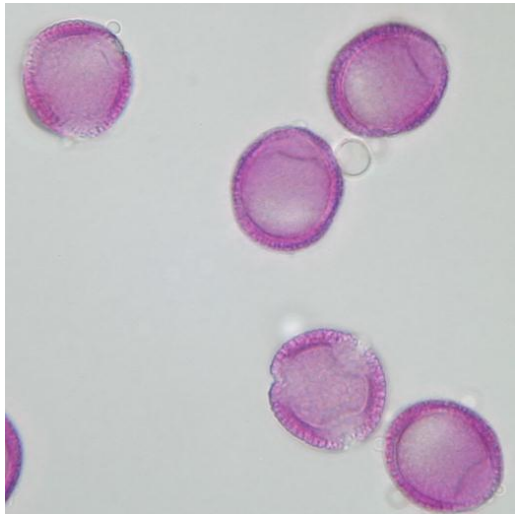
10 L/min

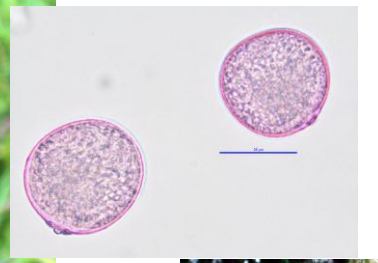
The drum



- 7 day;
- Particles impact over a adhesive tape embeded with silicon grease;
- Allows hourly analisys of the pollen and spores content in the air


Olea



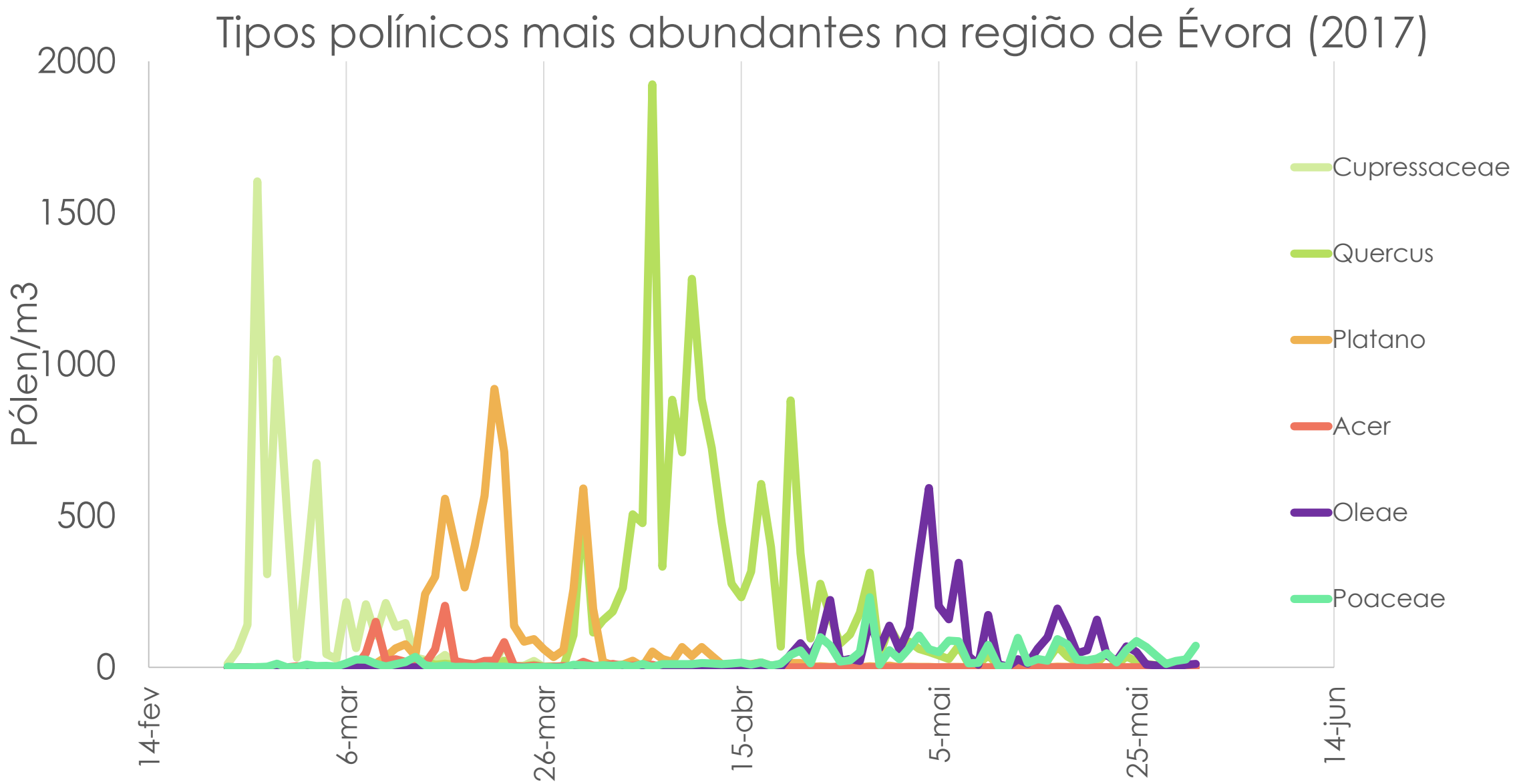



Phleum pratensis

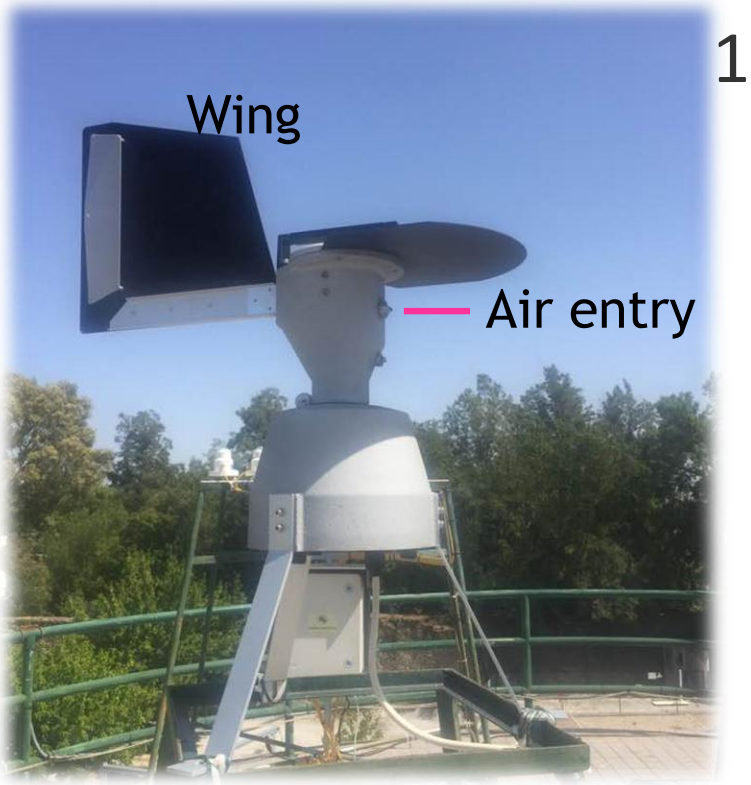

Quercus


Platanus hybrida


http://www.quaternary.group.cam.a
c.uk/pollen/articles/247/


Tipos polínicos mais abundantes na região de Évora (2017)
Pólen/m3
2000
1500
1000
500
0
14-fev
6-mar
26-mar
15-abr
5-mai
25-mai
14-jun
Cupressaceae
Quercus
Platano
Acer
Oleae
Poaceae

Hirts type pollen and spore trap – single stage



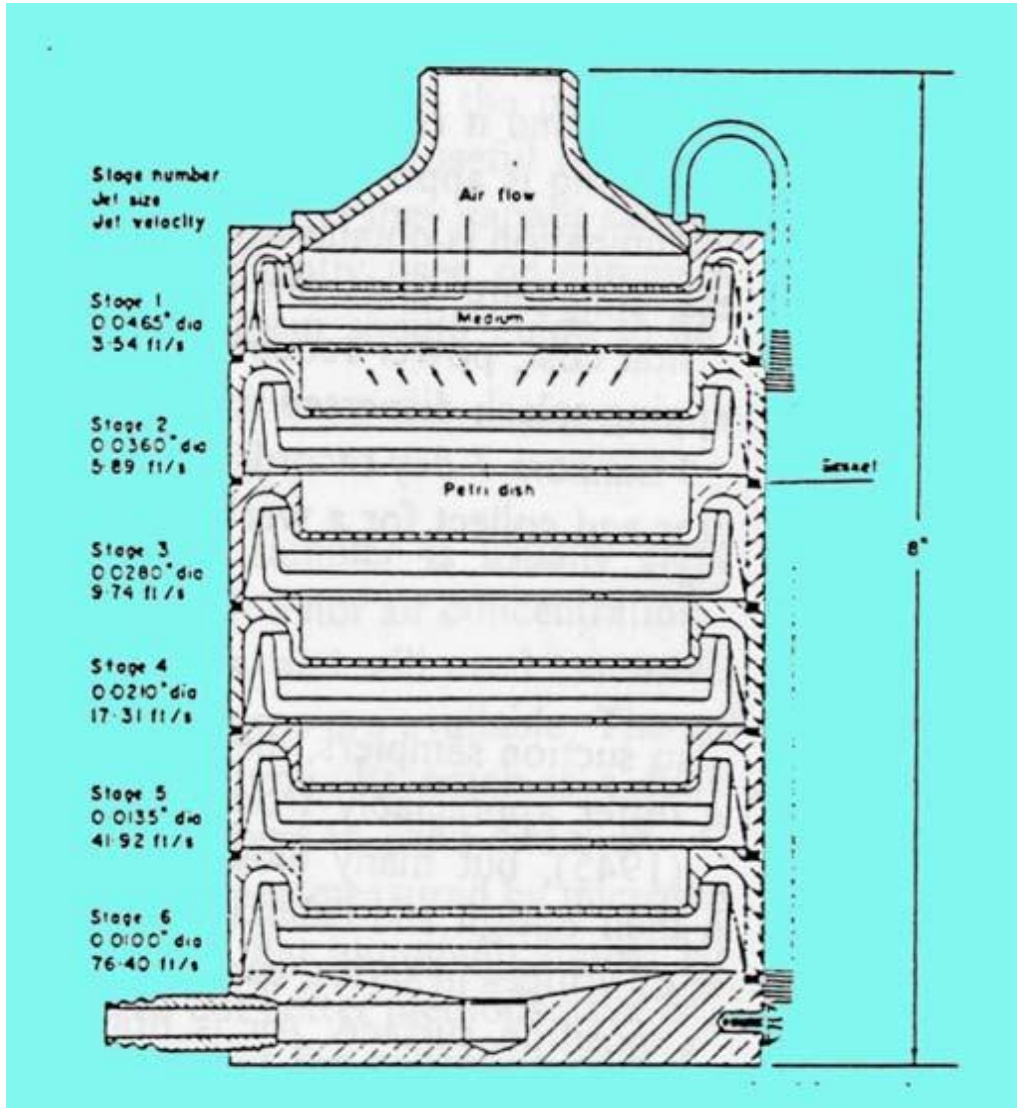
10 L/min

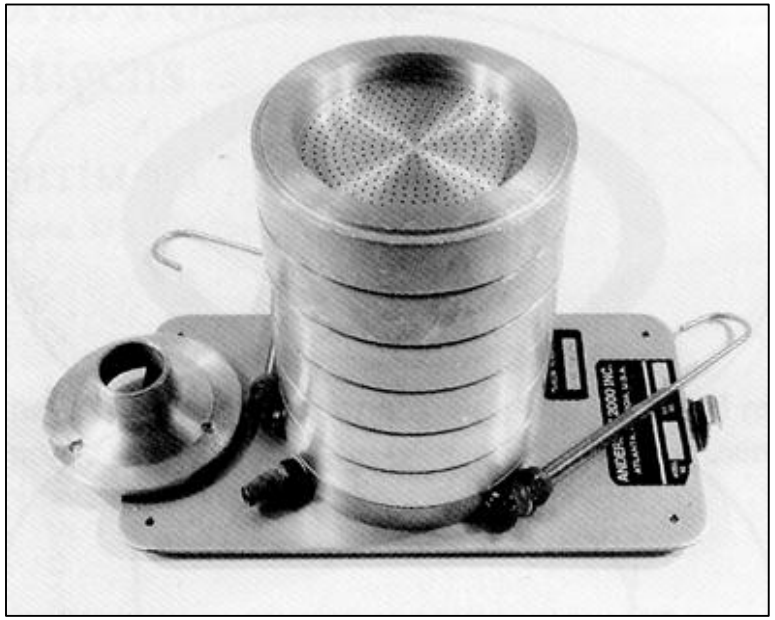
The drum

- 7 day;
- Particles impact over a adhesive tape (silicon grease embeded);
- Allows hourly analisys of the content of pollen and spores

NOT SUITABLE FOR SMALL PARTICLES NOR FOR BIOCHEMICAL ANALYSIS

Multi-stage impact - Andersen sampler

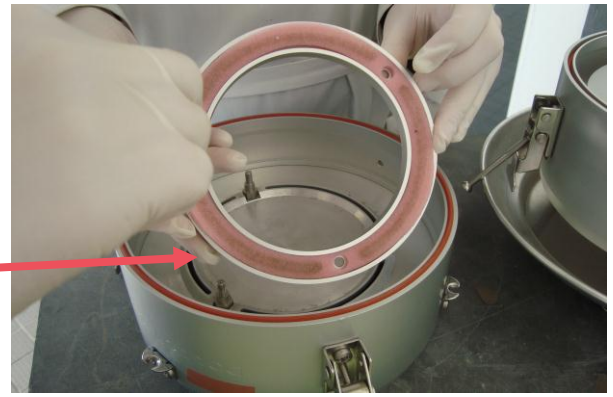




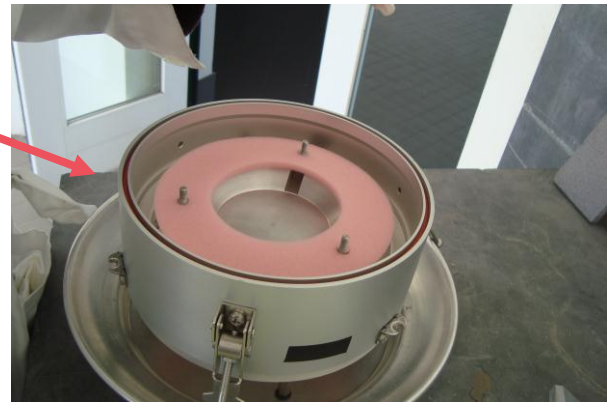
- 6 stages mimicking pulmonar deposition
- Fractionation of aerosols by size
- Top stage - PM>10µm
- Lower stages might have ultrafine fraction

Multi-stage impact - Chemvol 2400 sampler

2,5>PM>10µm



PM>10µm



Biochemical analysis

Impact subtrate processed

and the extract may be analysed:

- Protein contente
- allergen contente
- DNA analylis (PCR, etc)

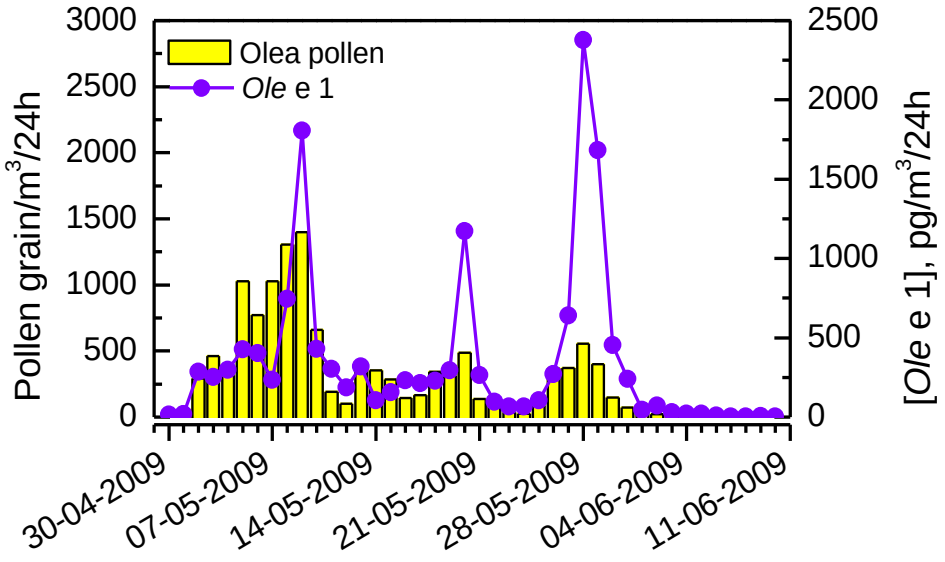
Considerable amount of material for biochemical analysis

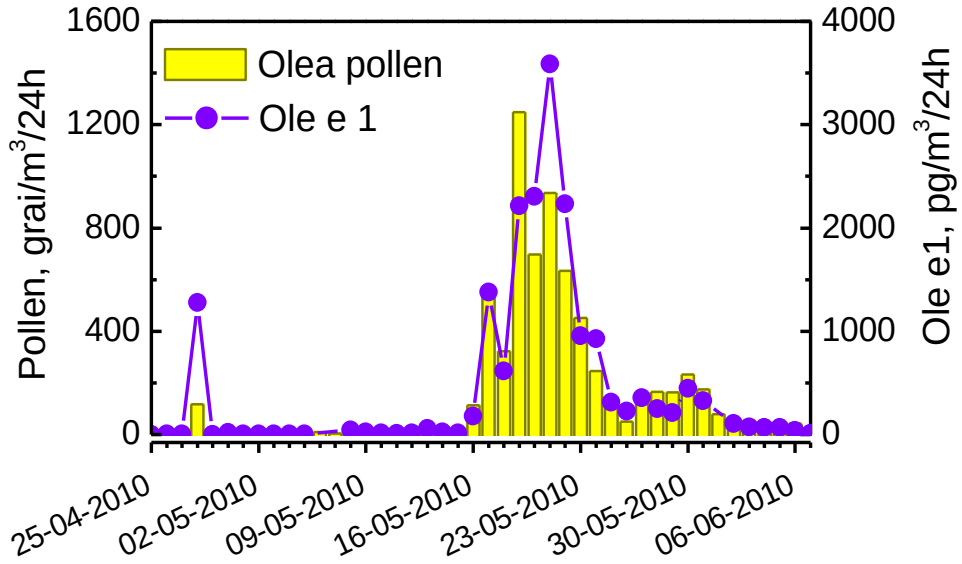
Metodos – Amostragem do Pólen e Alergeno Atmosférico

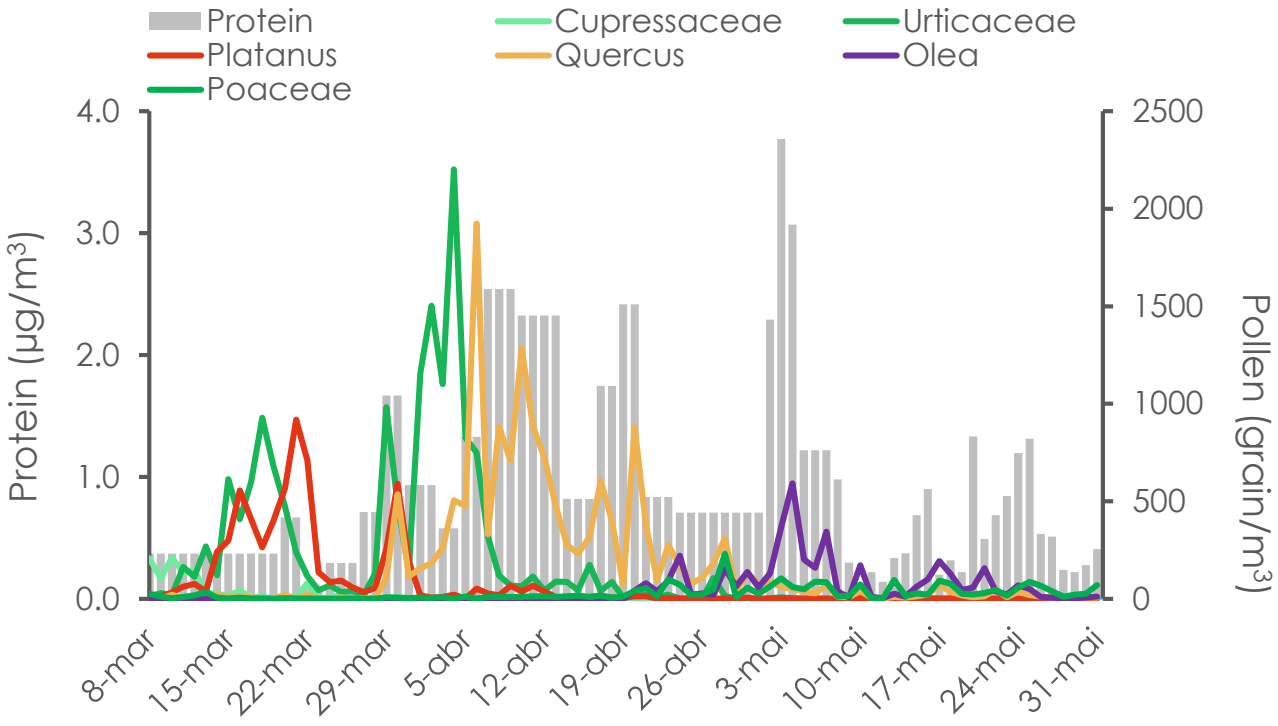
Monitorização dos Aeroalergenos
Colector de Impacto CHEMVOL 2400
800 L/min

Monitorização Polínica Colector tipo-HIRST 10 L/min

Allergens are proteins carried by pollen!!!







Cyclone sampler - µCoriolis

https://www.bertin-instruments.com/product/air-samplers/coriolis-micro-air-sampler/

Weight: - 3 kg (with battery)
Dimensions: 22 x 33 x 36 cm
Air flow rate: 100 to 300 L/min
Collection time: 1-10 min
Collected particle sizes: from 0.5 micro meter
Liquid output volume: 15 mL
Autonomy on battery: 1 hour
Decontamination: Hydrogen peroxide

PORTABLE
Adequate for microorganisms

Summary

Pollen and spore

Allergens / Protein / Toxins

Microorganisms

Allergen / Protein

Toxins / DNA

Relevance of lake / watershed to bioaerosol composition:

water surface emissions ≠ land emissions

Preliminary results on cyanobacterial aerosol emissions from the Alqueva reservoir, southern Portugal

E.A. Morales[1,2], C. Antunes[2], A. Costa[2] , M.J. Costa[2], M.H. Novais[1,2], M.A. Penha[1,2] & M.M. Morais[1,2]
[1]Laboratório da Água and [2]Instituto de Ciências da Terra, Universidade de Évora, Portugal
Presenting author email: mjcosta@uevora.pt

Laboratório da Água

Main Objective

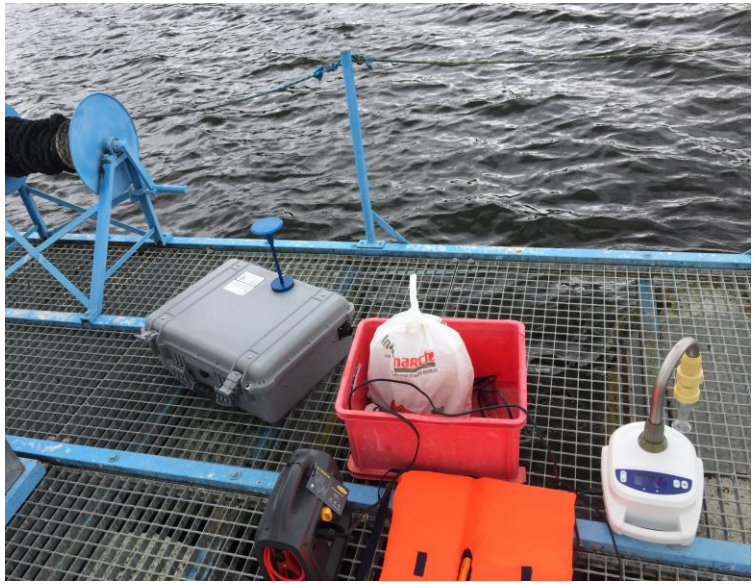
Detect cyanobacteria in aerosol samples, simultaneously testing the effectiveness of a novel sampling technique.

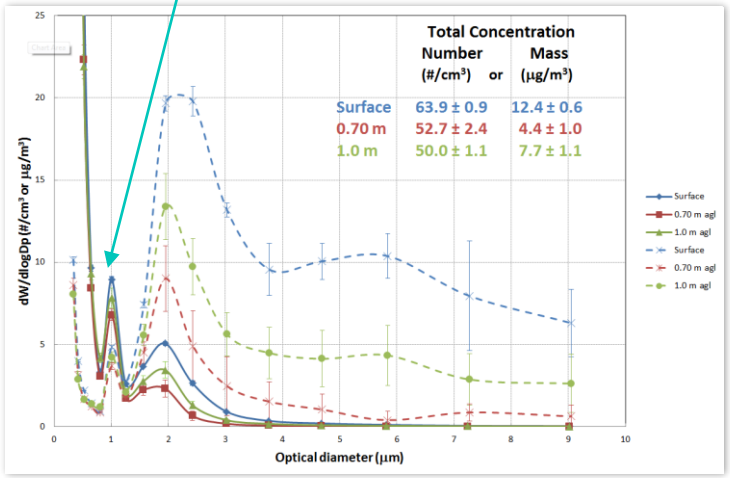
Justification

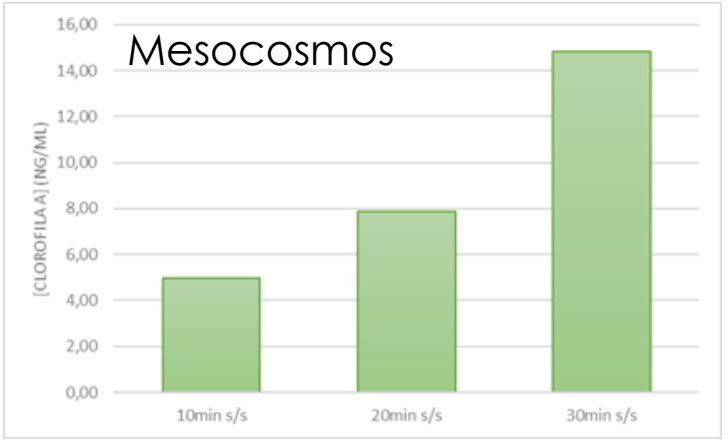
- **Blooms caused by cyanobacteria have increased worldwide**, probably due to climate change and to contamination of water bodies.
- **More than a quarter of blooming cyanobacteria are known to produce dermo-, hepato- and/or neurotoxins, which have adverse effects on animal and human health.**
- **Bioaerosols containing cyanobacterial cells and their toxins have been formally studied only twice** (Murby & Haney, 2016; May et al, 2018). This

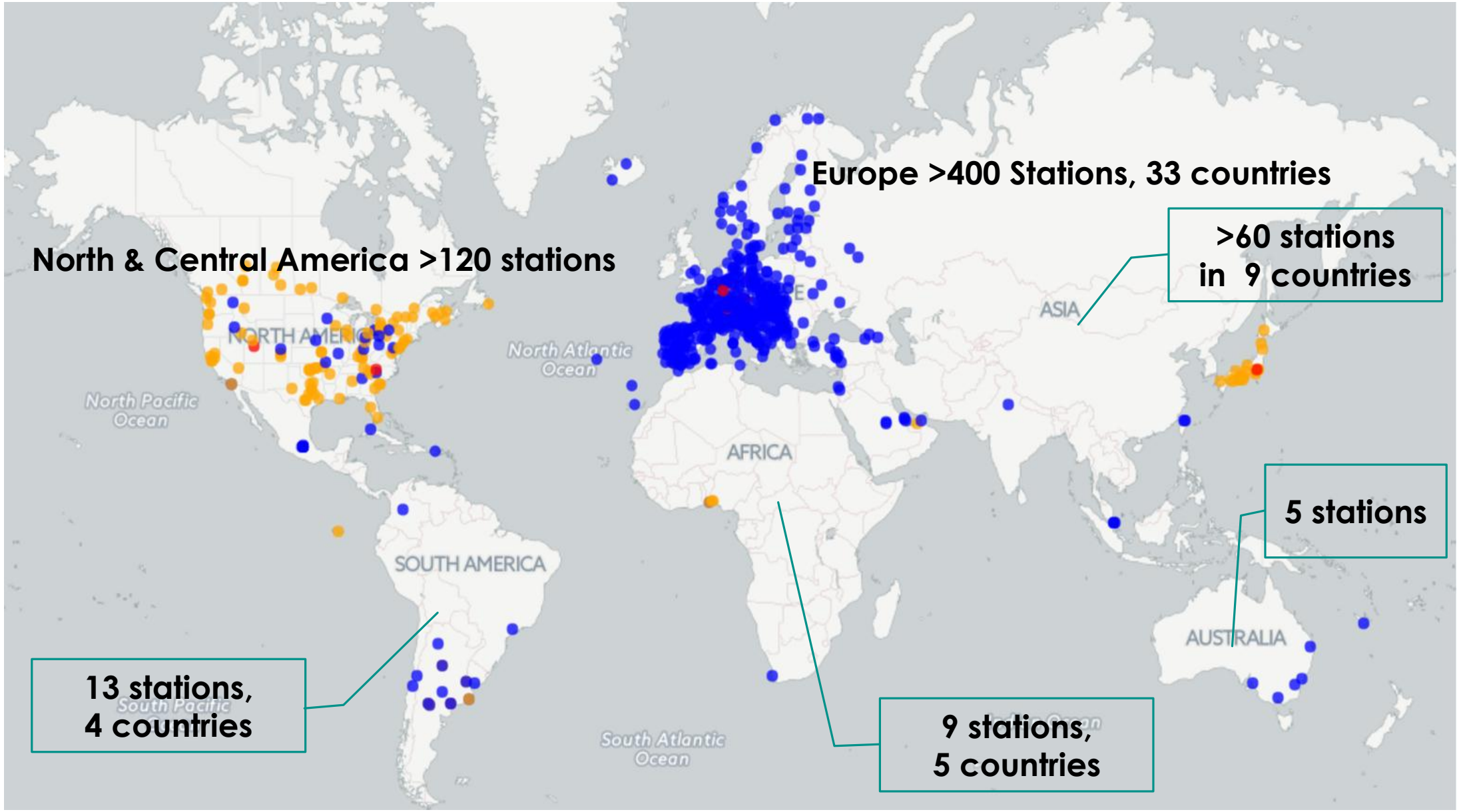
Results…

Bacteria / Cyanobacteria?



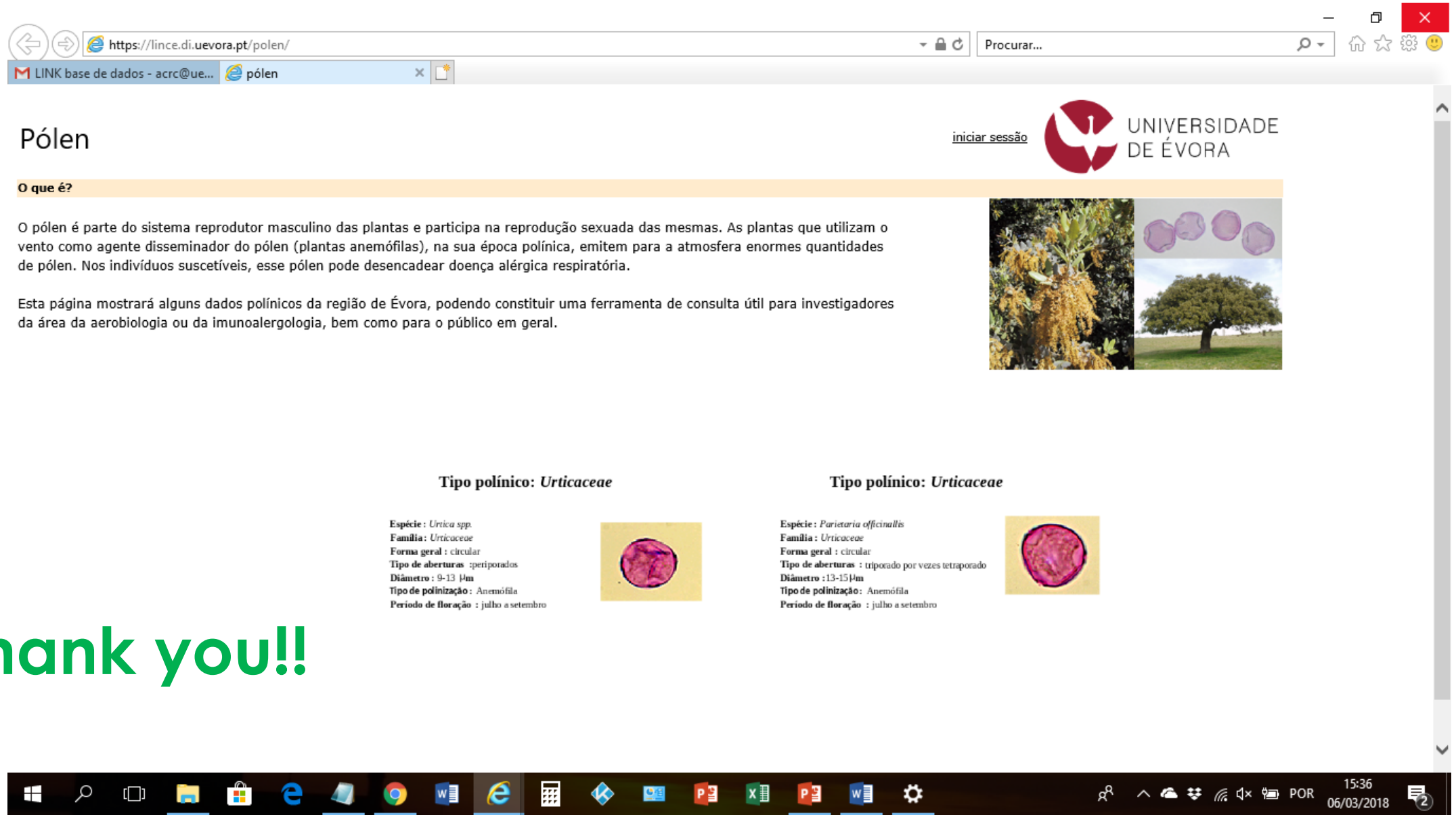






https://www.zaum-online.de/pollen-map.html

https://lince.di.uevora.pt/polen/



Thank you!!

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ICT

Obrigada pela vossa atenção !!