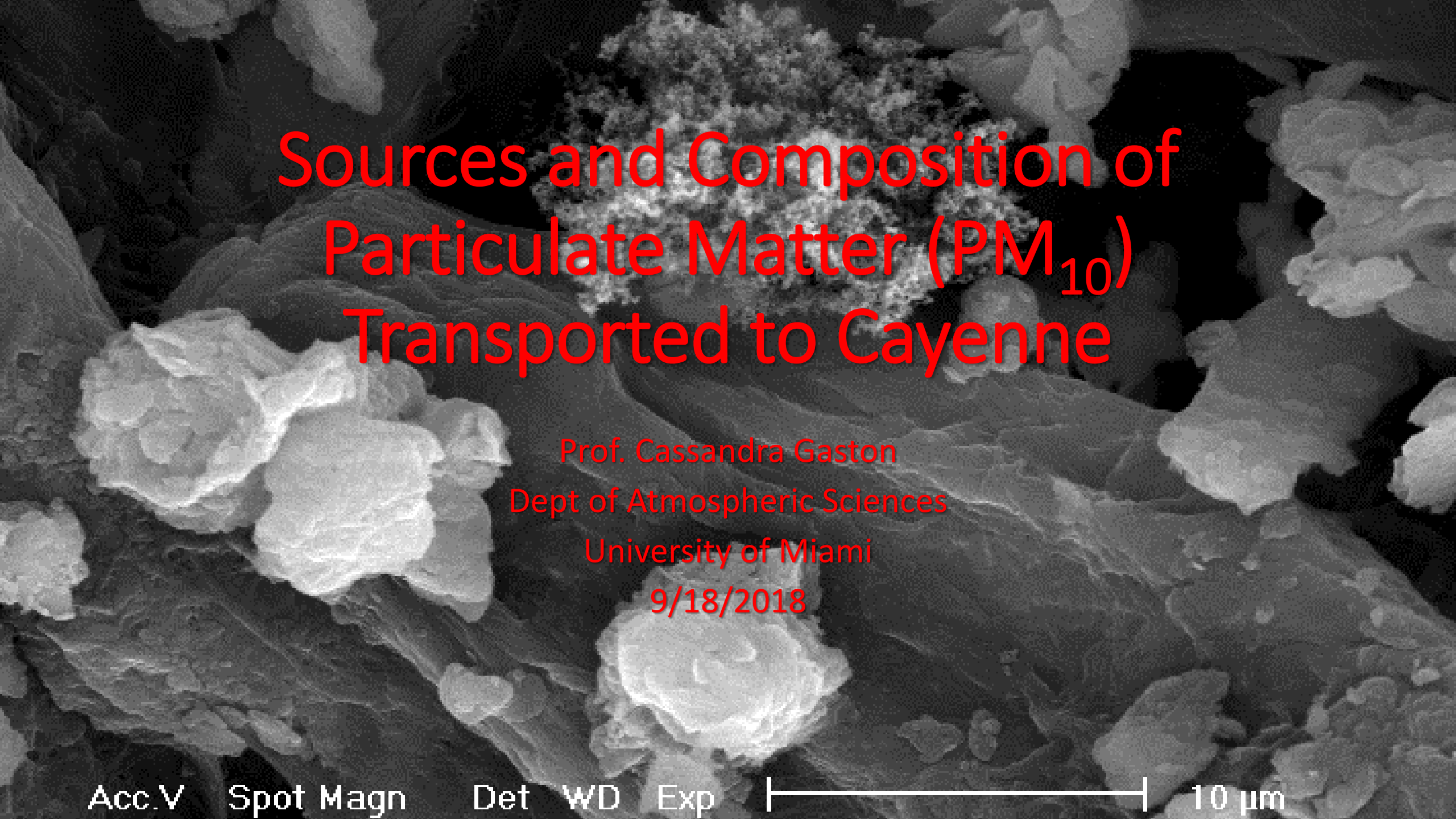
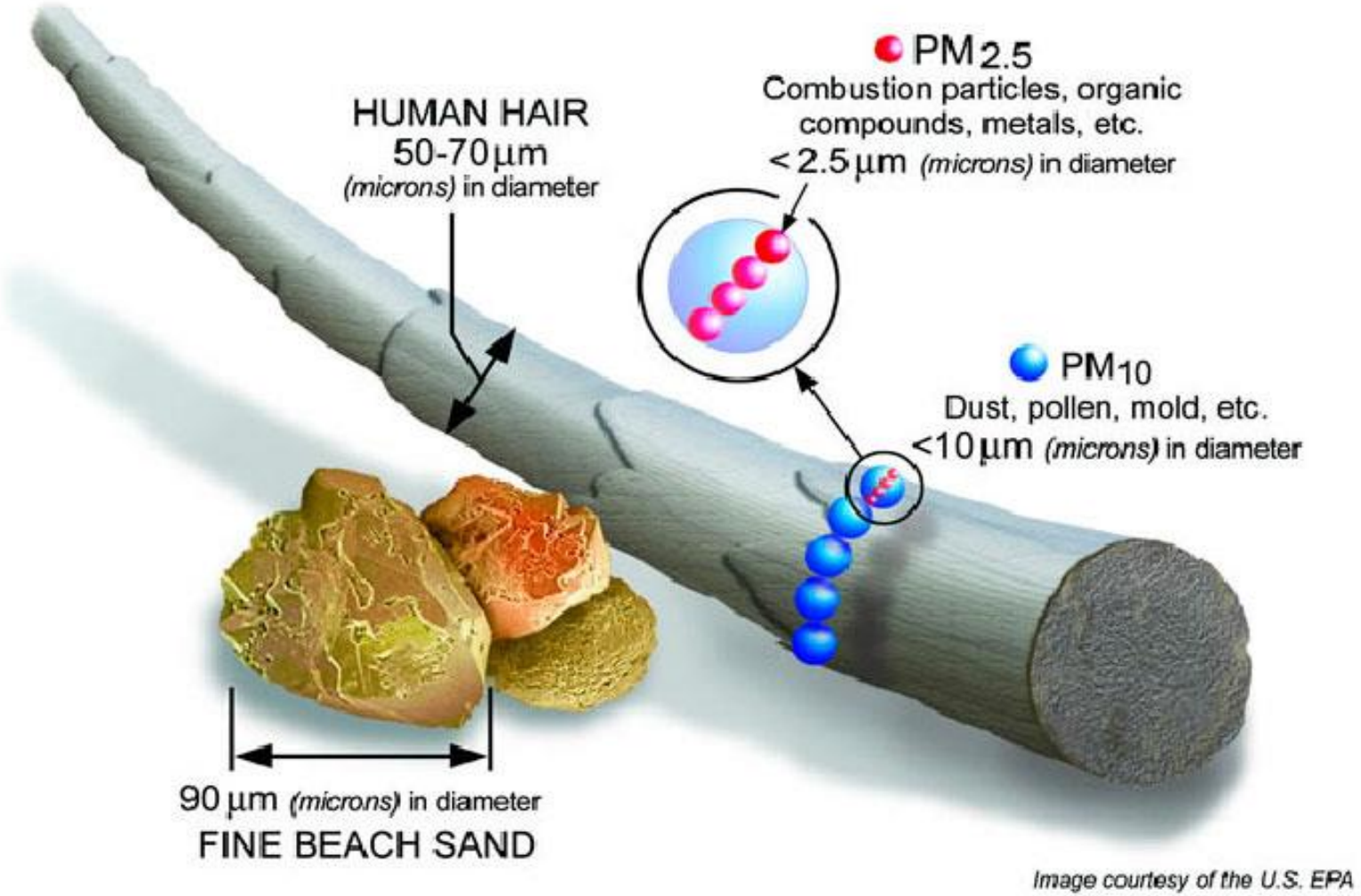


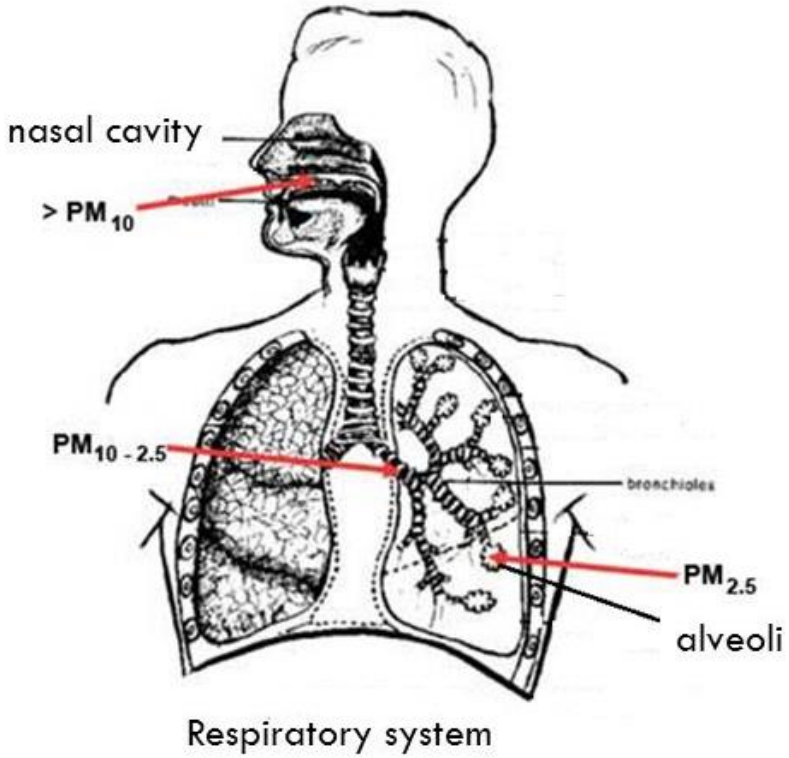
Sources and Composition of Particulate Matter (PM_{10}) Transported to Cayenne

Prof. Cassandra Gaston
Dept of Atmospheric Sciences
University of Miami
9/18/2018

Particulate Matter (PM) and Health

Particulate Matter or Aerosols are solids or liquids suspended in the atmosphere

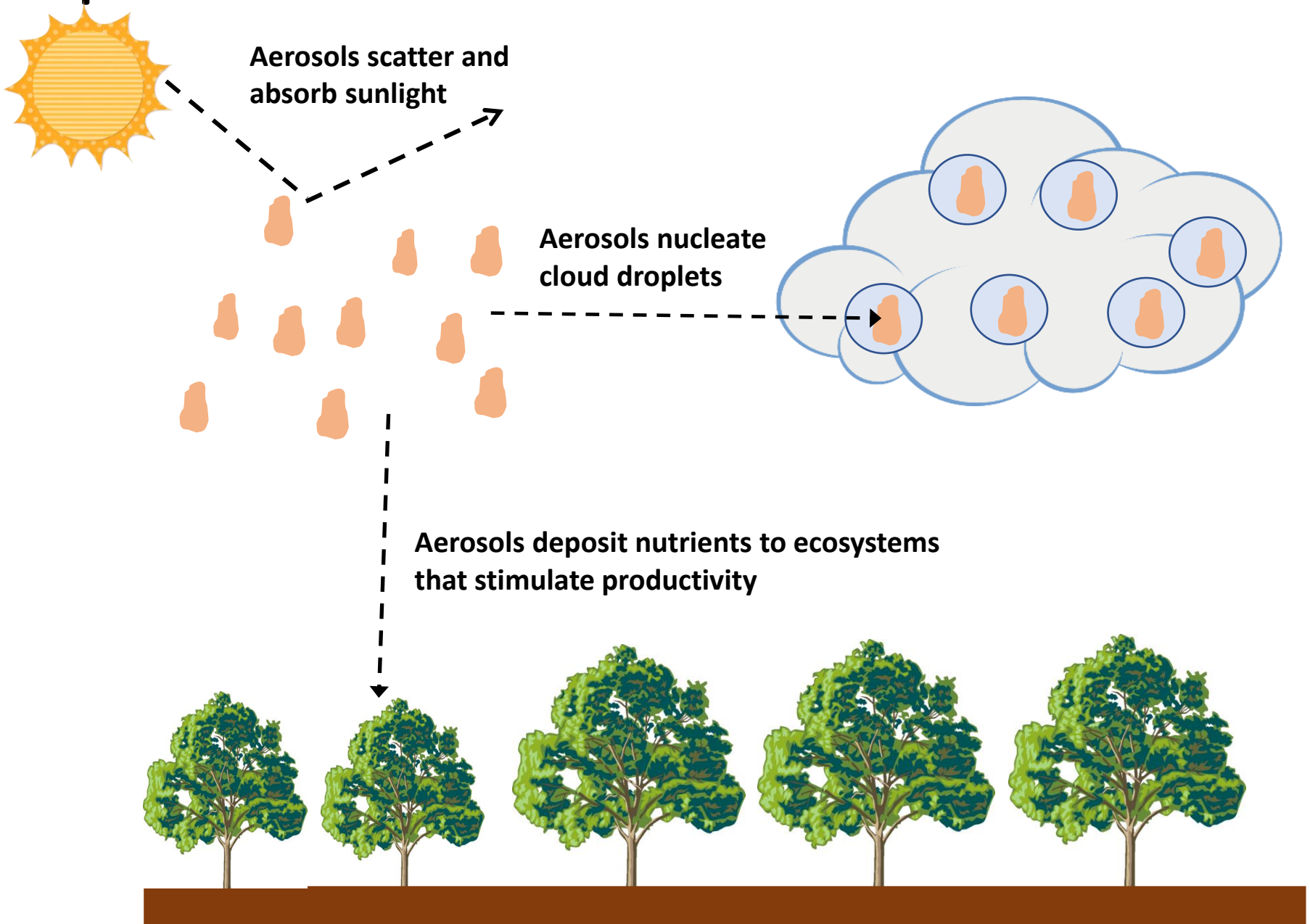


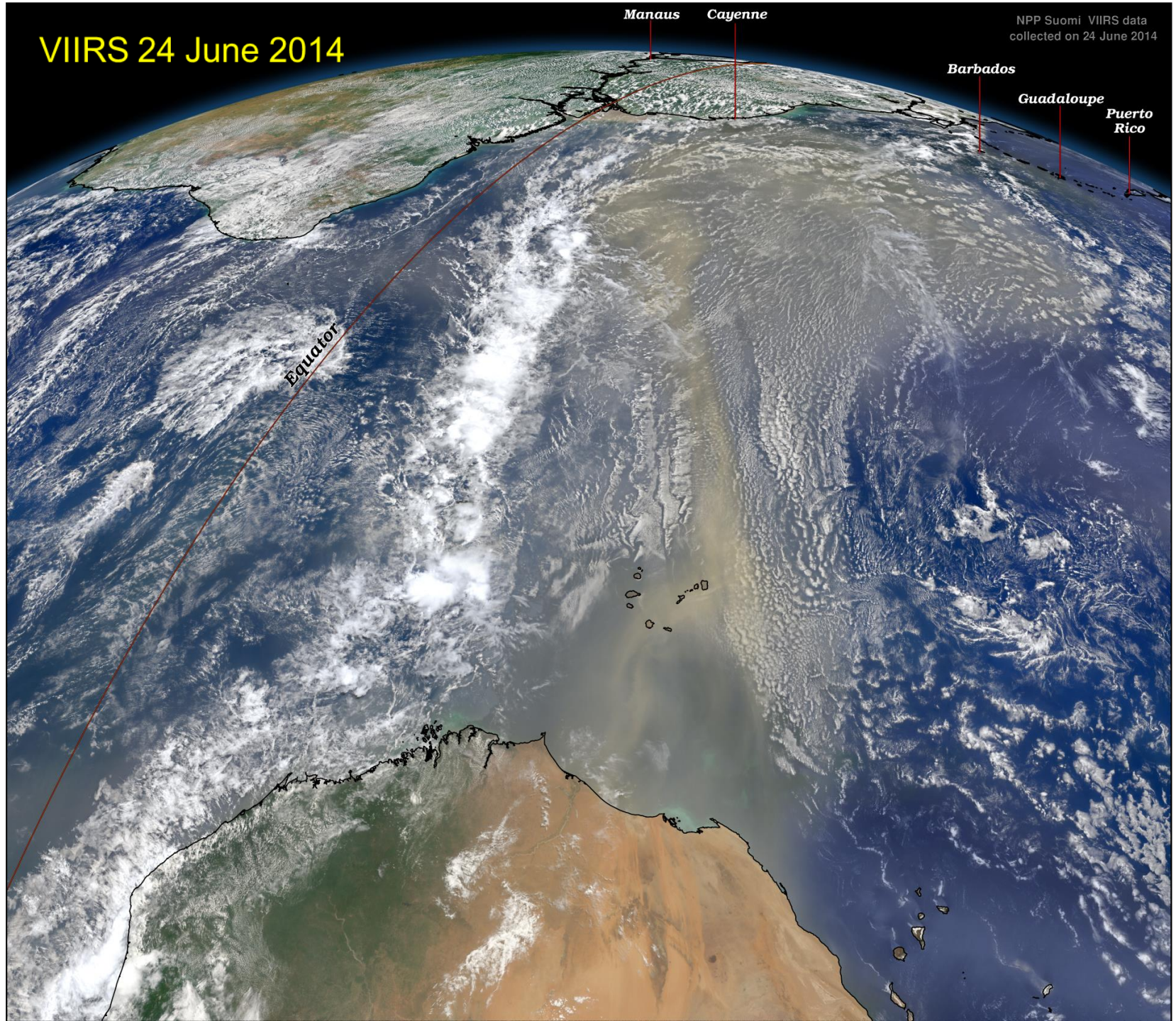


Respiratory system

Pope and Dockery, 2006

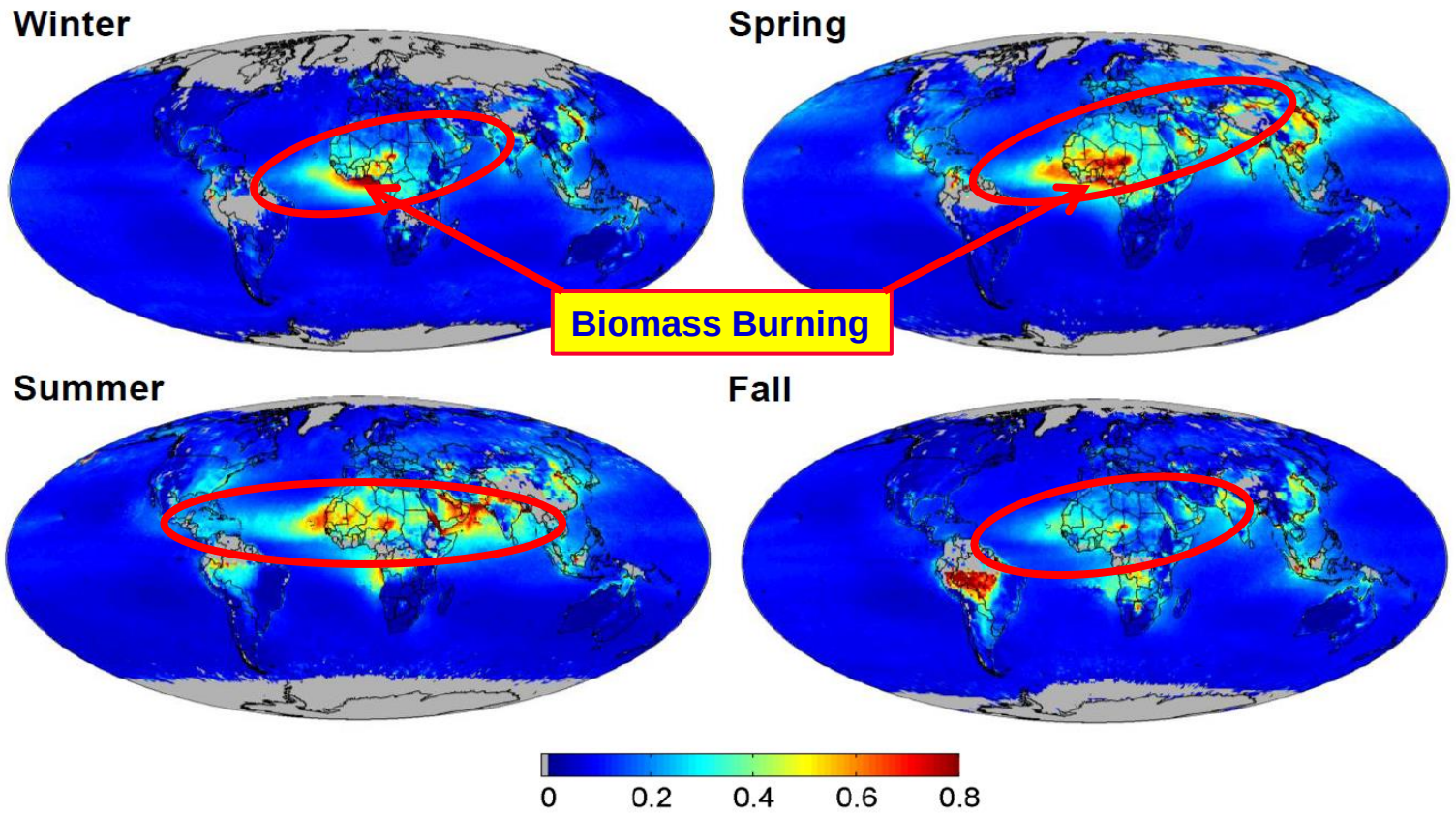
Impacts of Aerosols on Climate and Ecosystems




VIIRS 24 June 2014
NPP Suomi VIIRS data
collected on 24 June 2014
Manaus
Cayenne
Barbados
Guadaloupe
Puerto
Rico
Equator

Quantifying Dust Transport to South America

Satellite Aerosol Optical Depth (AOD) suggests strong transport to South America in winter and (especially) spring.

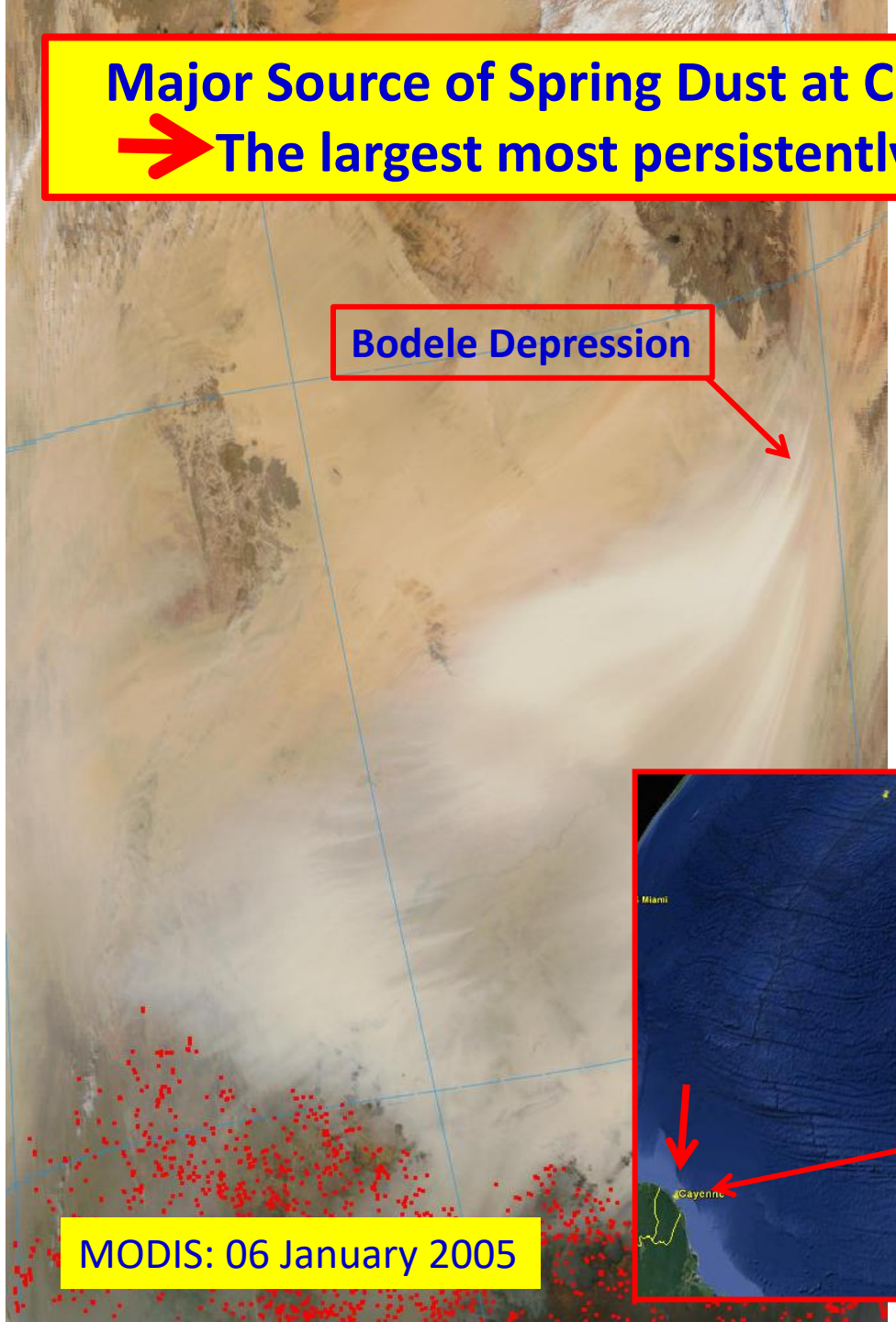


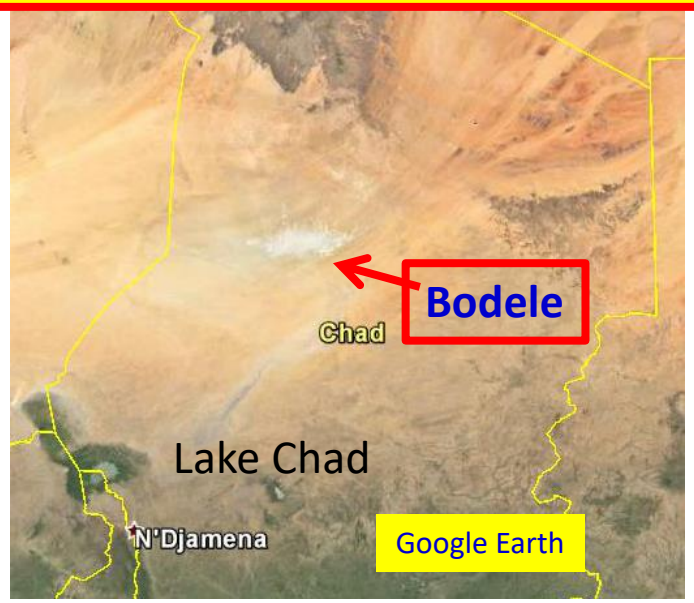
SeaWiFS seasonally averaged AOD at 550nm from 1997–2010. Hsu et al., 2012 ACP

Satellites suggest strong dust transport to Cayenne in Winter and Spring.
Interpretation complicated by strong biomass burning in winter and spring.

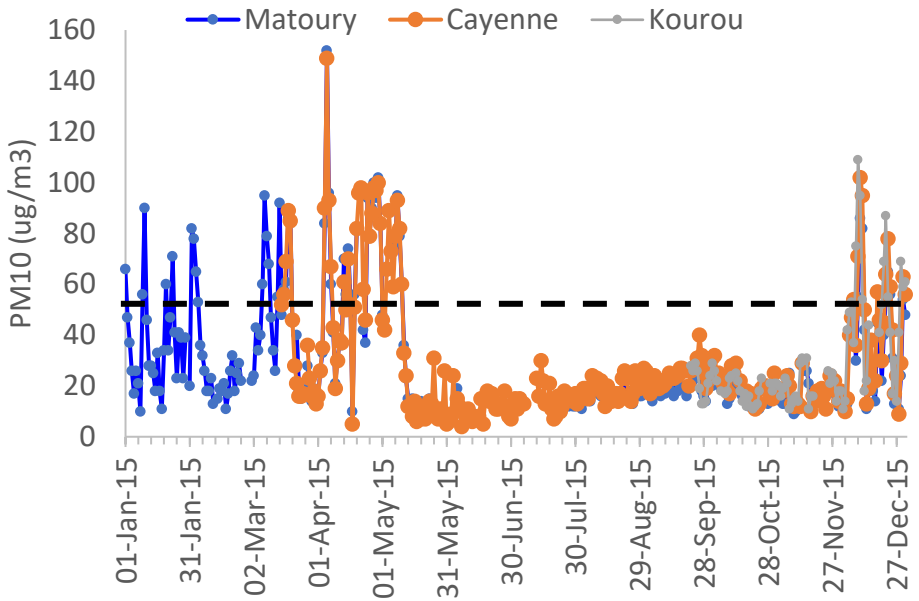
Major Source of Spring Dust at Cayenne: The Bodele Depression

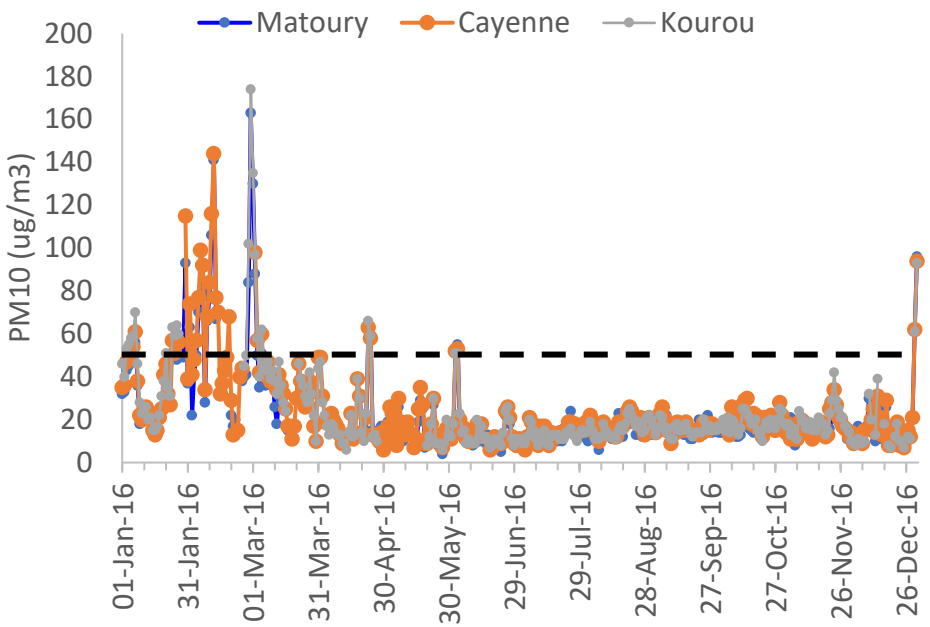
→ The largest most persistently active dust source in the world.

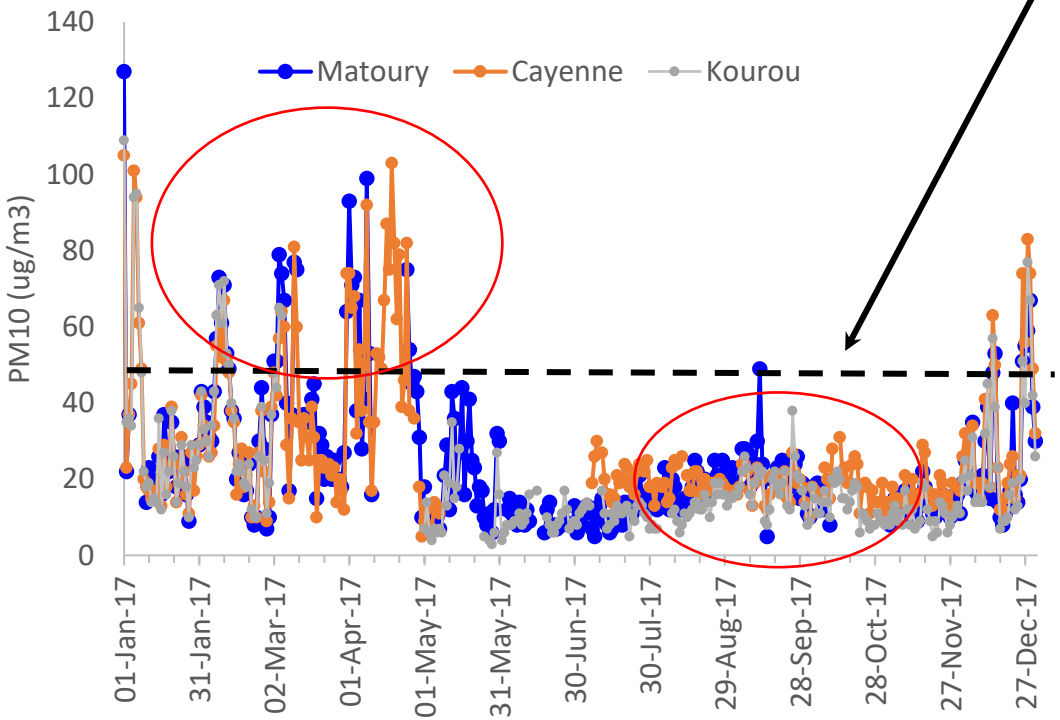




Particulate Matter (PM) Levels in Cayenne







World Health Organization (WHO) 24-hour air quality guidelines for PM_{10} (i.e., 50 mg/m^3)

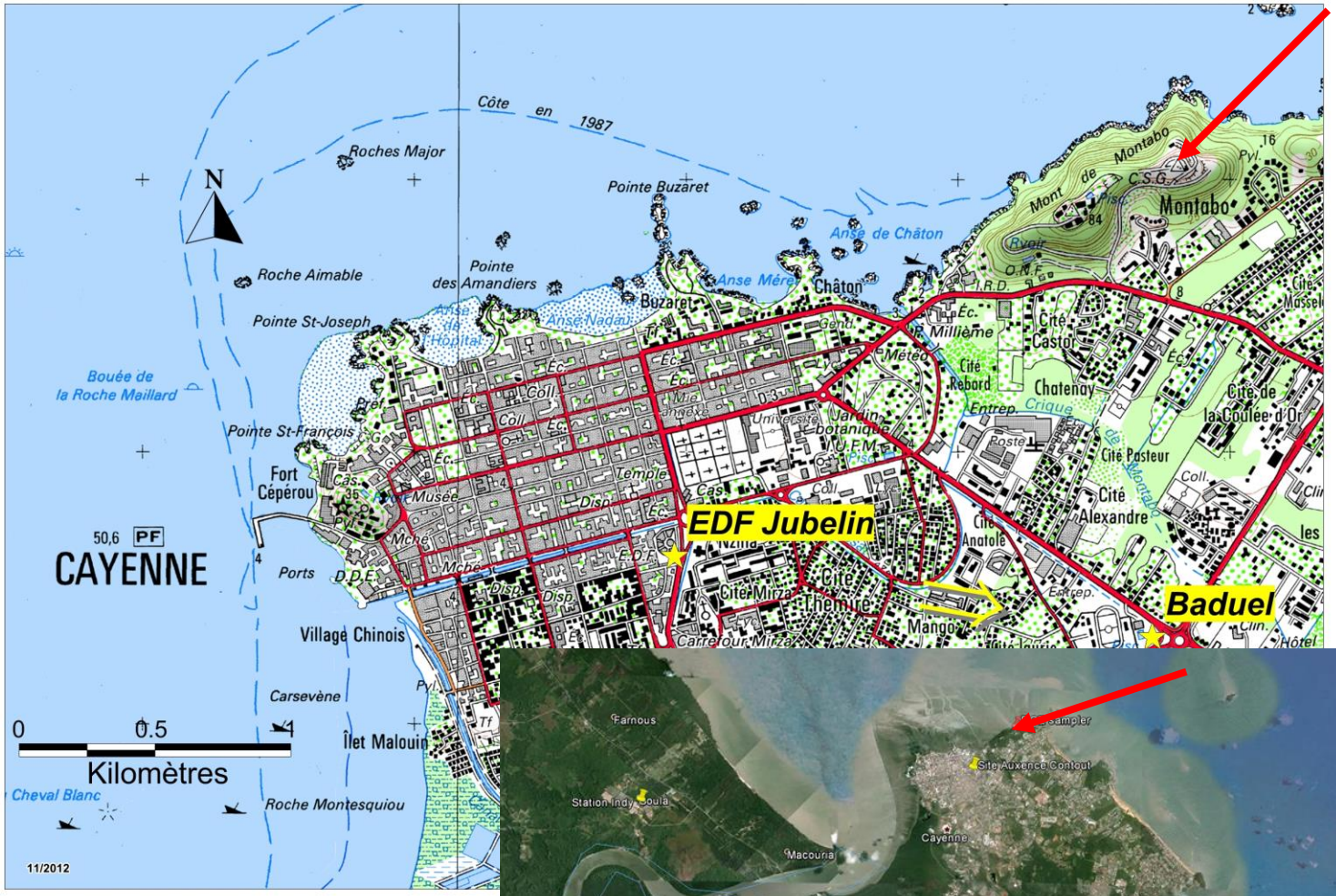
Questions

- **What are the sources of aerosols that explain observations of PM_{10} particularly during conditions when PM_{10} exceeds 50 ug/m^3?**

- **Are there seasonal differences in the composition of aerosols in Cayenne?**

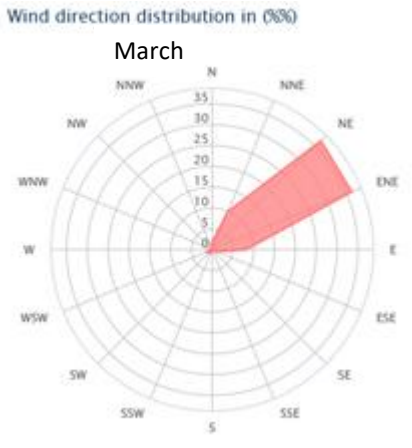
- **What are the environmental impacts of PM_{10}?**

2014: Began Hi-Vol Aerosol Sampling at Cayenne



Cayenne metro: 130,000 population.

In collaboration with ATMO-Guyane



Filters Collected in Cayenne

- Filter measurements first led by Dr. Joe Prospero and continued by the Gaston group
- Filters sent to University of Miami for chemical analysis and measurements of concentrations of African dust
- Further analysis of individual particles using University of Miami's microscopy center

Photo of high volume air sampler in Cayenne

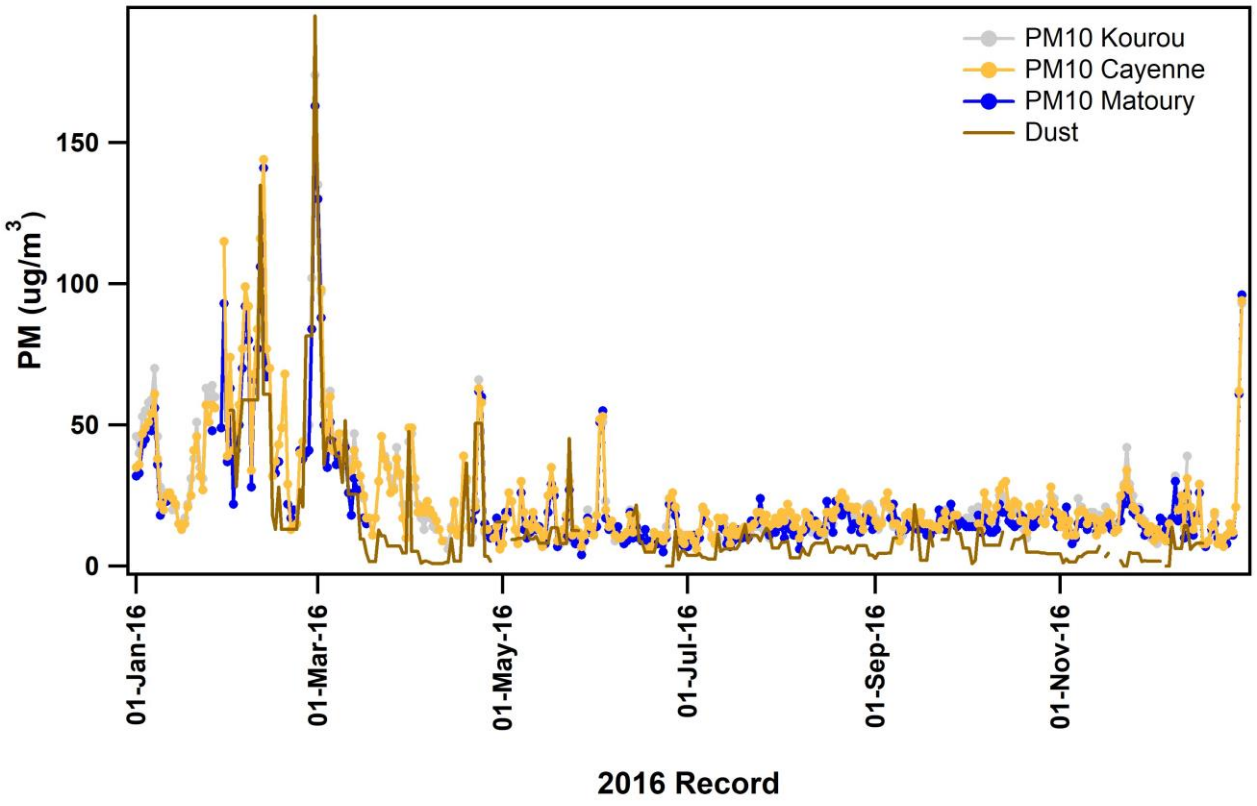
Comparison of TEOM Record to Dust Mass Concentrations

- Transported African dust explains most of the PM_{10}, particularly in winter and spring

- Episodic events can transport dust with concentrations far exceeding the air quality standard recommended by the WHO (e.g., > 50 ug/m^3)

Questions:

1. is the dust from the Bodélé?
2. Is biomass burning aerosol also transported?



Barkley et al., 2018 In Prep

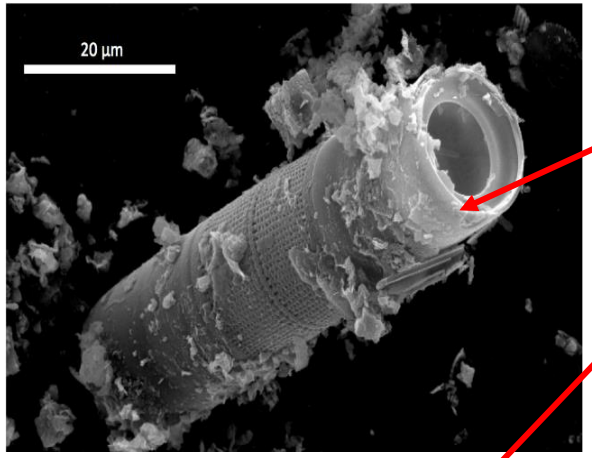
Single Particle Measurements to Link Particles to Their Sources

- Scanning Electron Microscopy (SEM) to determine the size and shape of individual particles
- Energy Dispersive X-ray Spectroscopy (EDS) to determine the elemental composition of individual particles
- SEM-EDS can be used to source apportion 100s of particles from the filters

Photo of microscopy center at the University of Miami

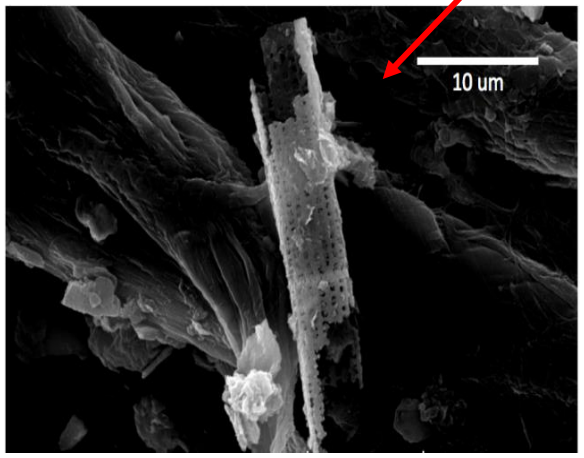
Evidence of PM Transport from the Bodélé Depression to Cayenne

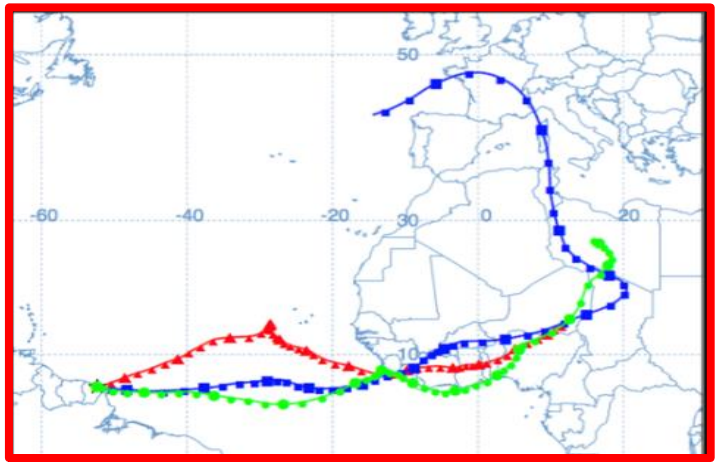
Particles from a soil sample collected at the Bodélé Depression



From SEM images, fossilized diatoms from the Bodélé Depression are transported to Cayenne

Particles from filters collected in Cayenne



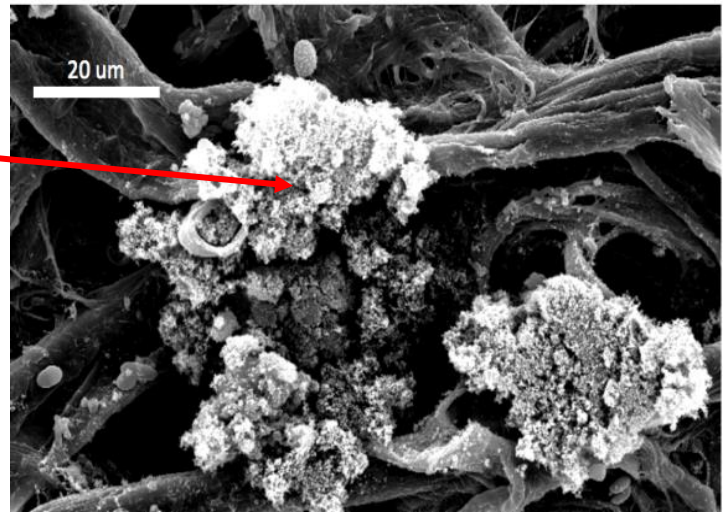


Air mass back trajectory showing transport from the Bodélé Depression

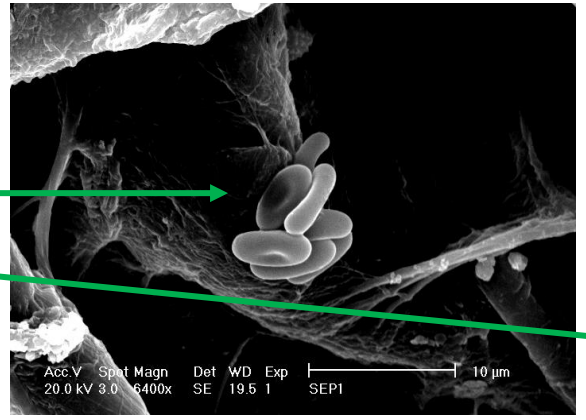
Barkley et al., 2018 In Prep

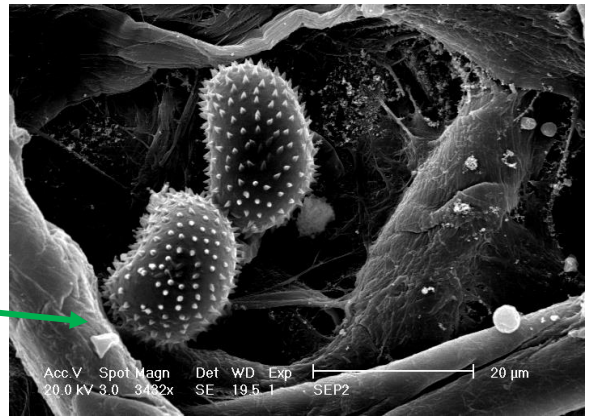
PM Sources Other than African Dust

Soot particles from biomass burning aerosol



Biological material

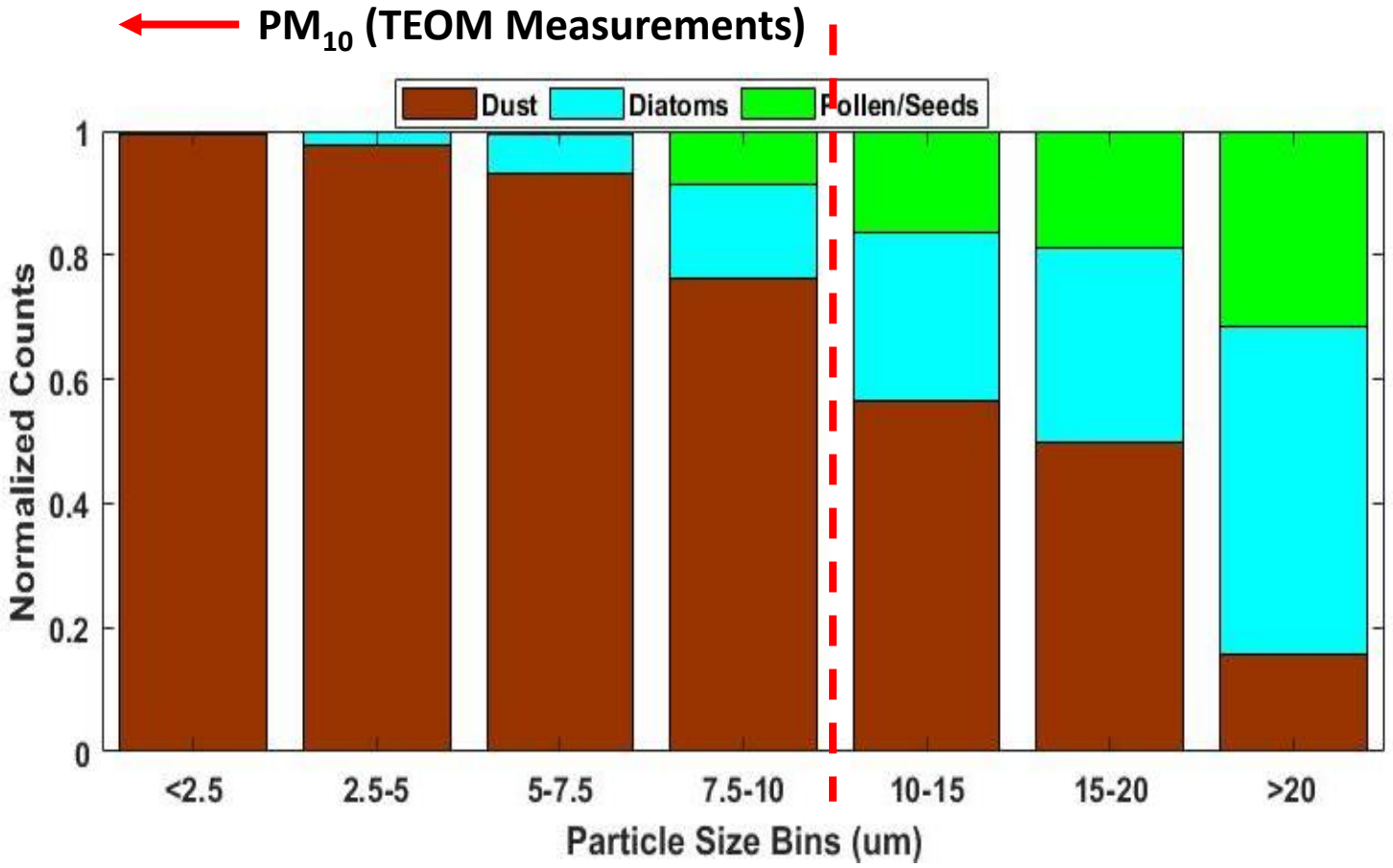




Barkley et al., 2018 In Prep

Size Distribution of Particles Measured in Cayenne

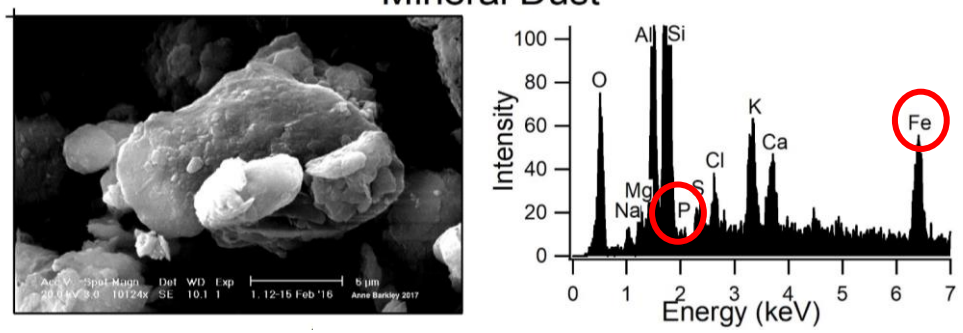
- Dust is the dominant contributor to PM_{10} based on SEM measurements
- Biological aerosols and diatoms also contribute, but mainly to particles larger than PM_{10}



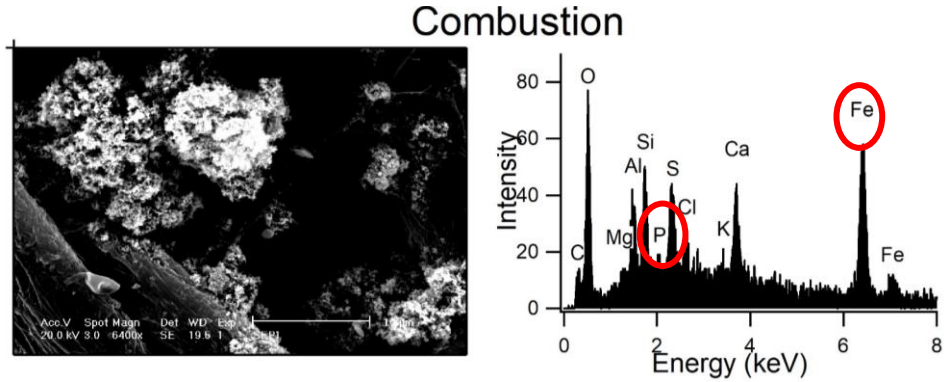
Barkley et al., 2018 In Prep

Composition of Individual Particles Detected in Cayenne

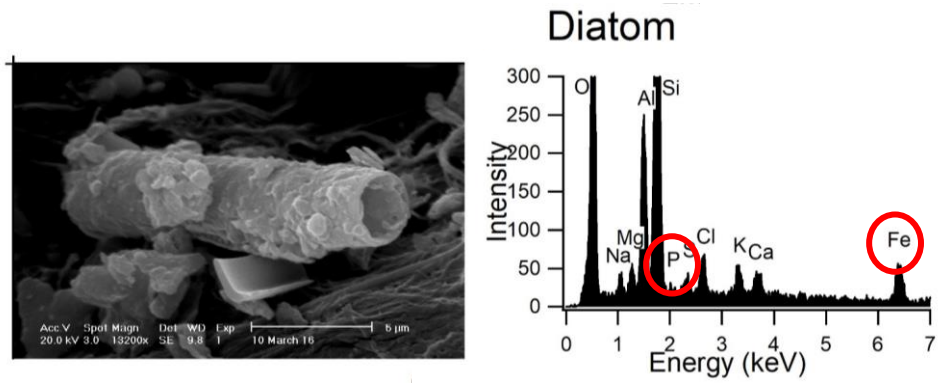
Mineral Dust



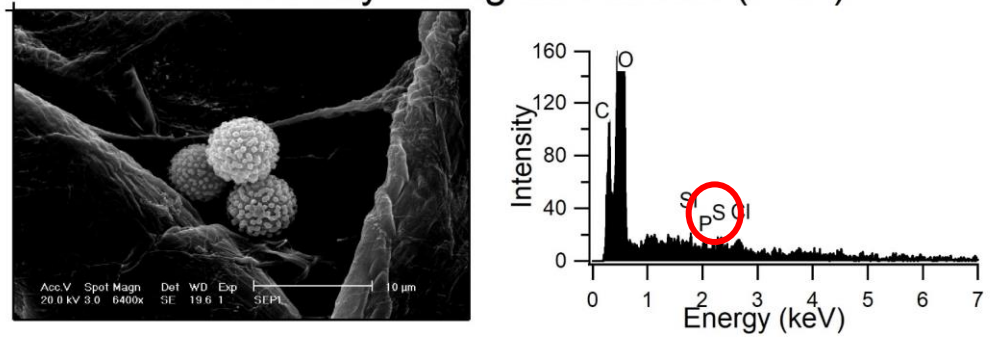
Combustion



Diatom



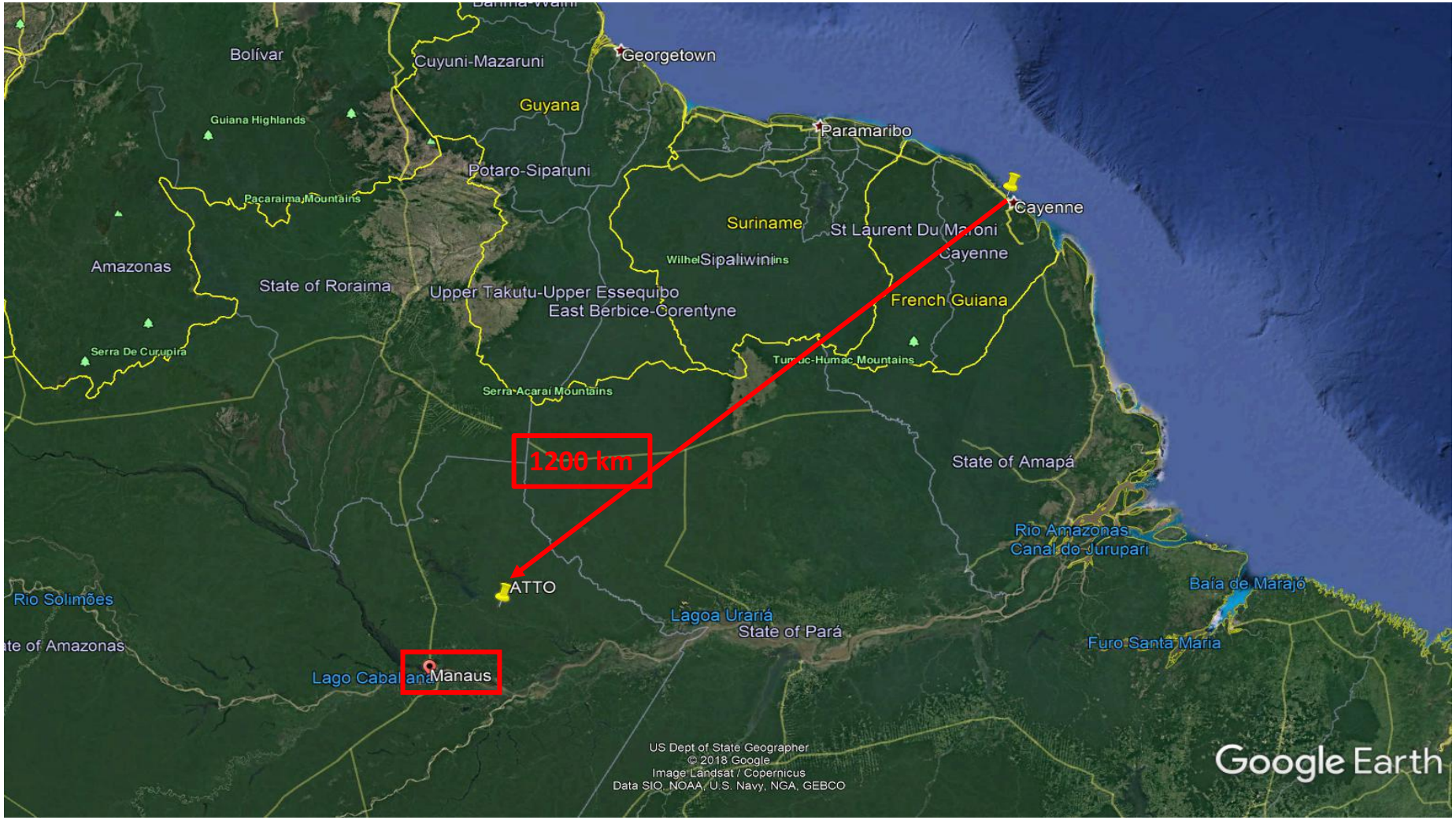
Primary Biological Aerosol (PBA)



Barkley et al., 2018 In Prep

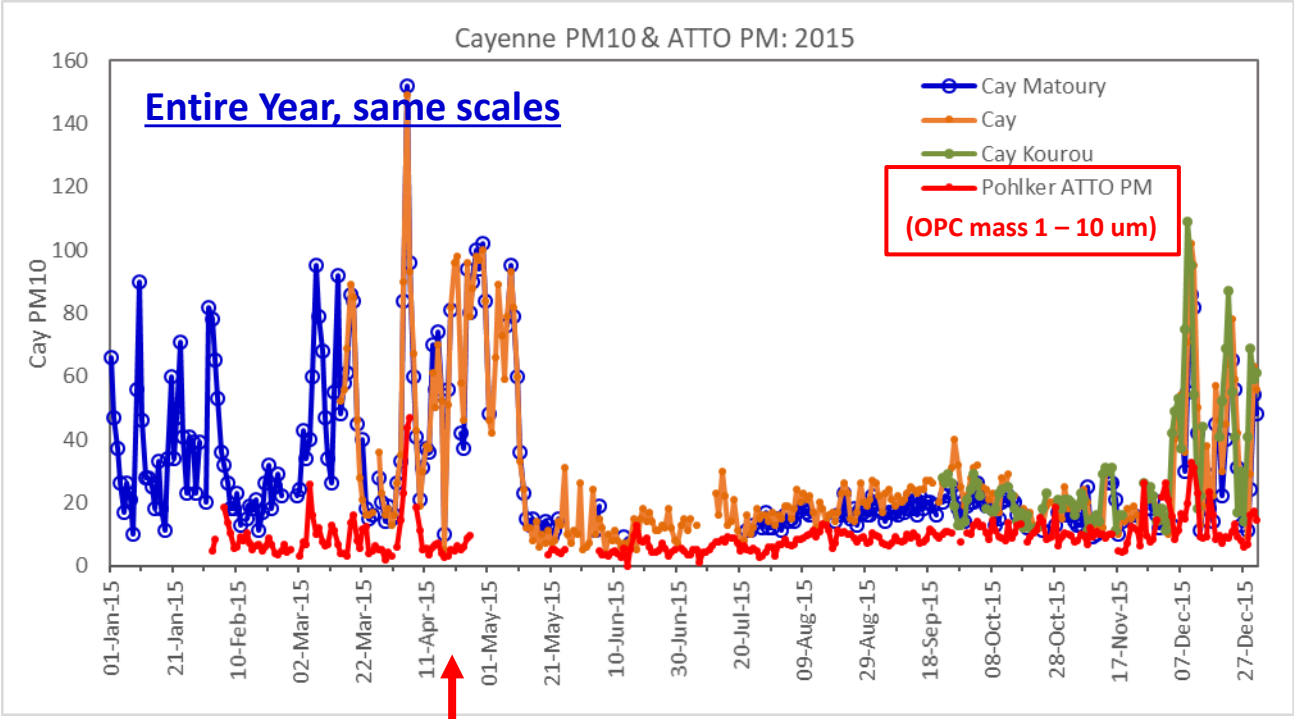
Transport to the Amazon Tall Tower Observatory (ATTO)

Amazon Tall Tower Observatory (ATTO): Two 80m towers at the site since 2012, and recently a new 325m tower.



Andreae, M. O., et al. (2015), The Amazon Tall Tower Observatory (ATTO): Overview of pilot measurements on ecosystem ecology, meteorology, trace gases, and aerosols, ACP, 2015,

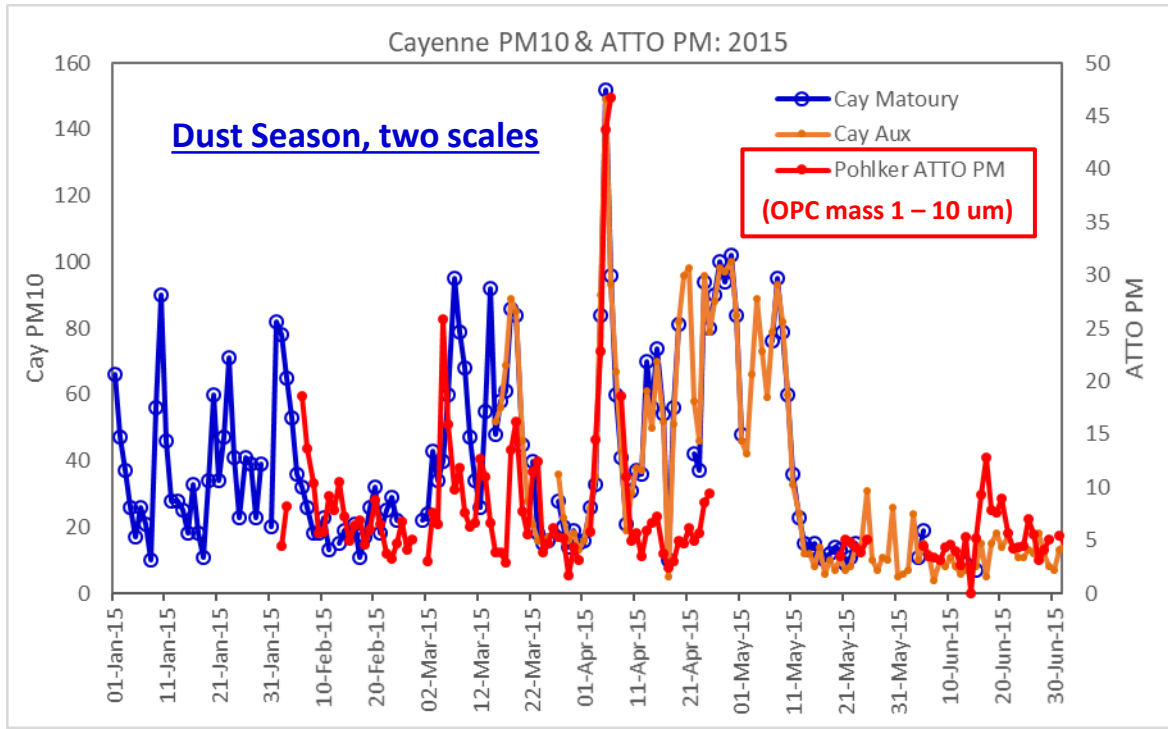
Comparing Cayenne TEOM PM10 with ATTO OPC PM 1-10: 2015



Pohlker et al.: Used OPC. Calculated the mass for particles from 1 to 10 µm. Moran-Zuloaga, D., et al. (2017), Long-term study on coarse mode aerosols in the Amazon rain forest with the frequent intrusion of Saharan dust plumes, Atmos. Chem. Phys. Discuss., 2017, 1-52, doi:10.5194/acp-2017-1043.

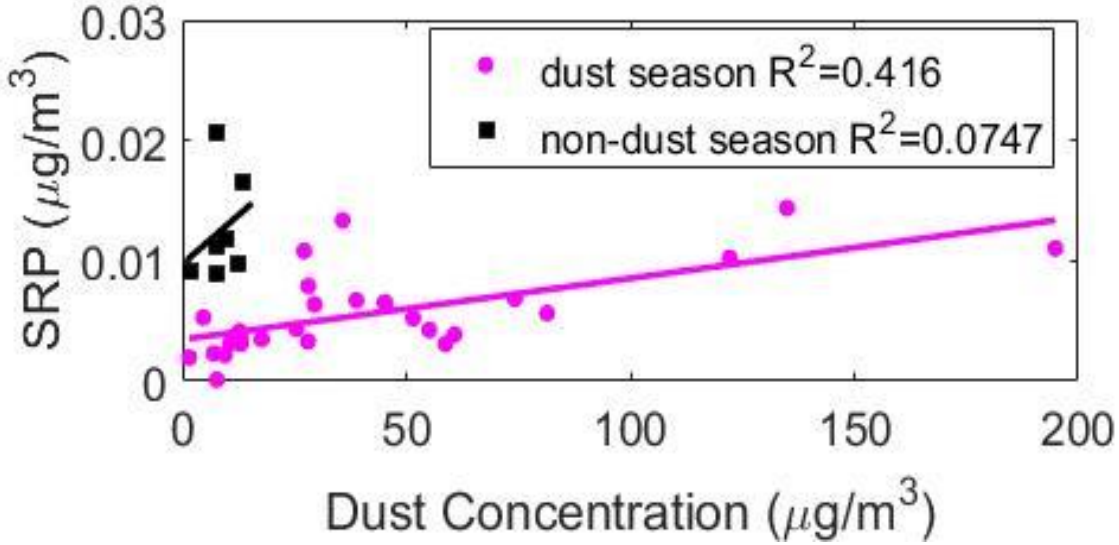
Transit time Cayenne - ATTO about 24 – 36 hours.

- Yet some peaks are congruent!



Aerosolized Nutrients Associated with African Dust Transported to Cayenne

Approach: We measured phosphorus and its solubility from filter samples



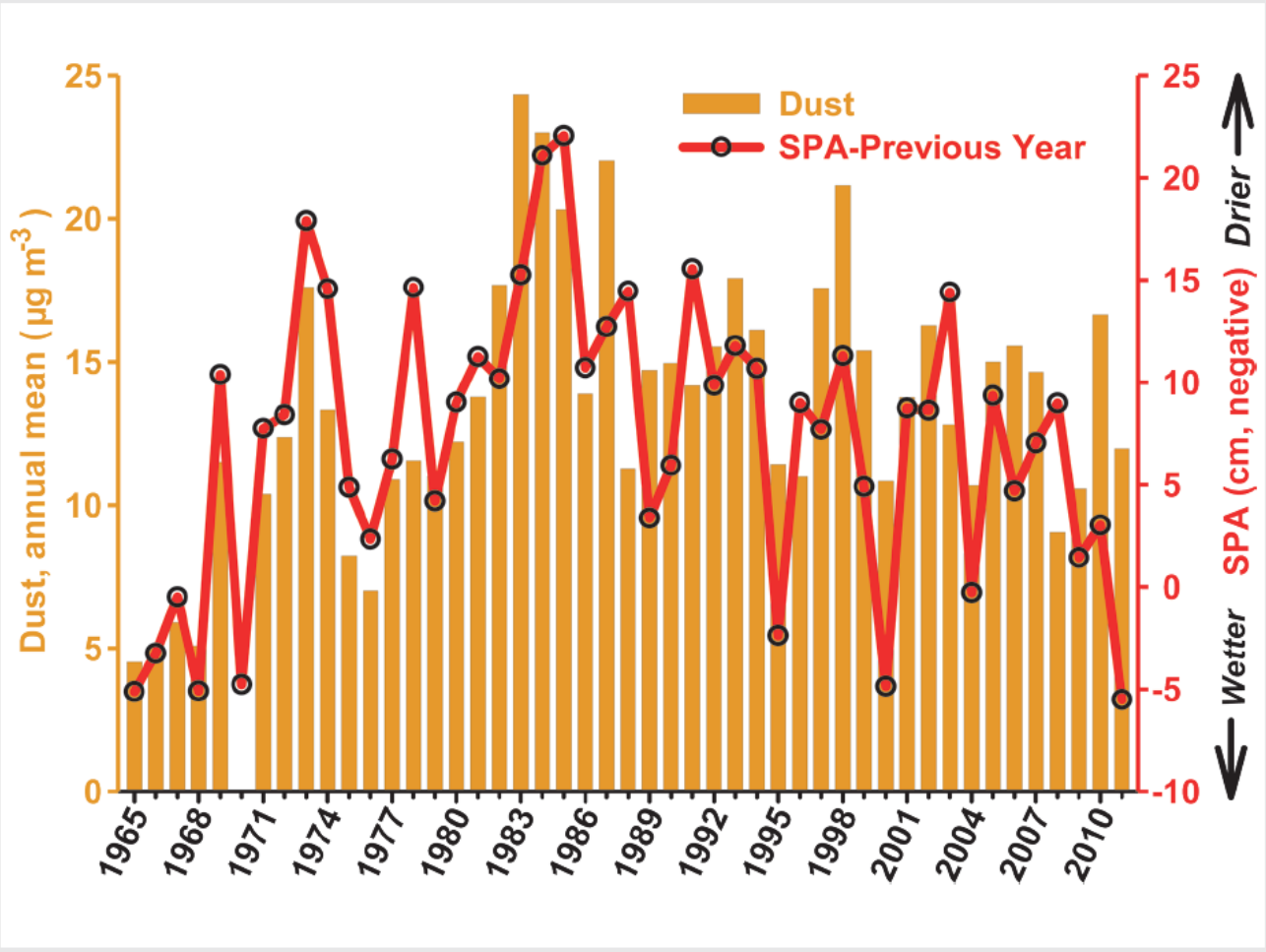
African dust transported to Cayenne is associated with aerosolized soluble phosphorus

Want to know more? Anne Barkley will present her results at this year's American Geophyiscal Union conference in Washington D.C.

Summary and Conclusions

- PM_{10} measurements from TEOMs in French Guiana show episodic exceedances of 50 ug/m^3
- African dust explains periods of high PM_{10} mass concentrations
- Dust from the Bodélé Depression is transported to Cayenne
- Other particle sources observed using microscopy are combustion particles and biological material
- African dust contains nutrients that is important for ecosystem health in South America and the Amazon

Future Directions: Long Term Measurements in Cayenne



In Cayenne, we want similar comparisons of long-term dust variability and indices of precipitation and other climatic factors that could affect dust transport

Prospero 2014

Acknowledgments

- ATMO Guyane
  - Kathy Panechou-Pulcherie
  - Alex Gatineau
  - Francois-Xavier Collard
  - Alexis Jannot
- Anne Barkley (U. Miami)
- Joe Prospero (U. Miami)
- Kim Popendorf (U. Miami)
- Pat Blackwelder (U. Miami)
- Andrew Ault (U Michigan)