AFRICAN DUST AND PM_{10} AT CAYENNE, BARBADOS, AND GUADELOUPE: IMPACT ON AIR QUALITY IN THE CARIBBEAN BASIN AND SOUTH AMERICA

THE 5Th INTERNATIONAL CONFERENCE ON MEDICAL GEOLOGY

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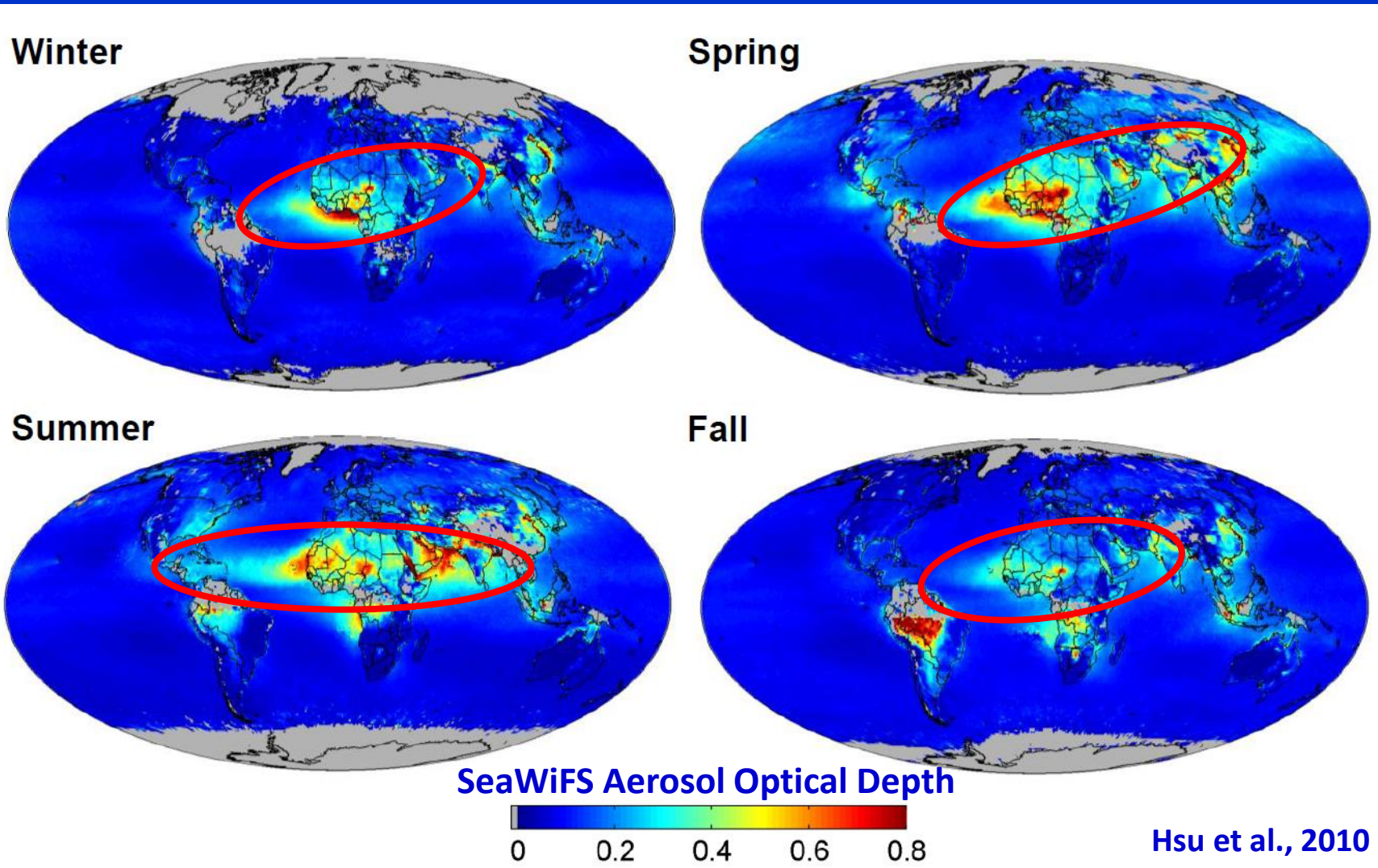
Why the Interest in Mineral Dust and Health?

- Dust is one of the most widespread aerosol species in the atmosphere.
- Huge areas are covered by dust a large portion of the year.
- Dust can be transported great distances – impact distant populations.
- BUT: few measurements of dust in "clean" environments.

Primary Focus of this Presentation

- Present PM10 measurements from Cayenne and Guadeloupe.
- Show that PM10 is largely attributable to African dust.
- Show that PM10 levels are comparable to urban areas in Europe and US.
- Discuss relationship of dust variability in terms of African sources/climate.

Satellites: Global Distribution of Aerosols – Dominance of Dust

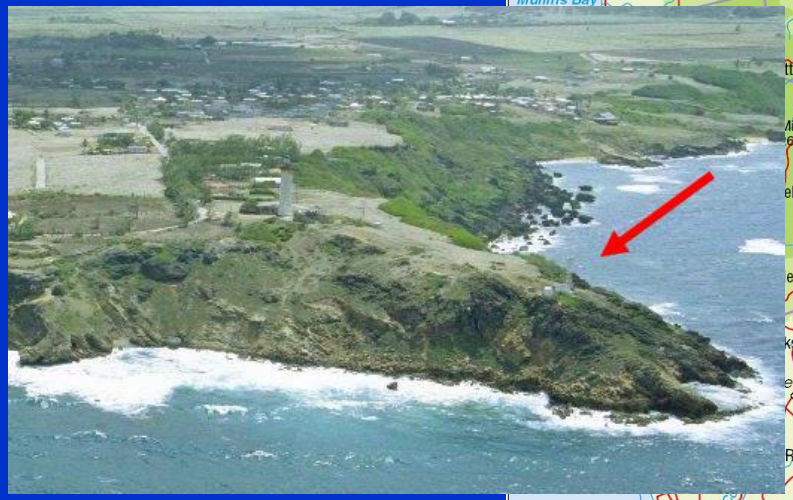


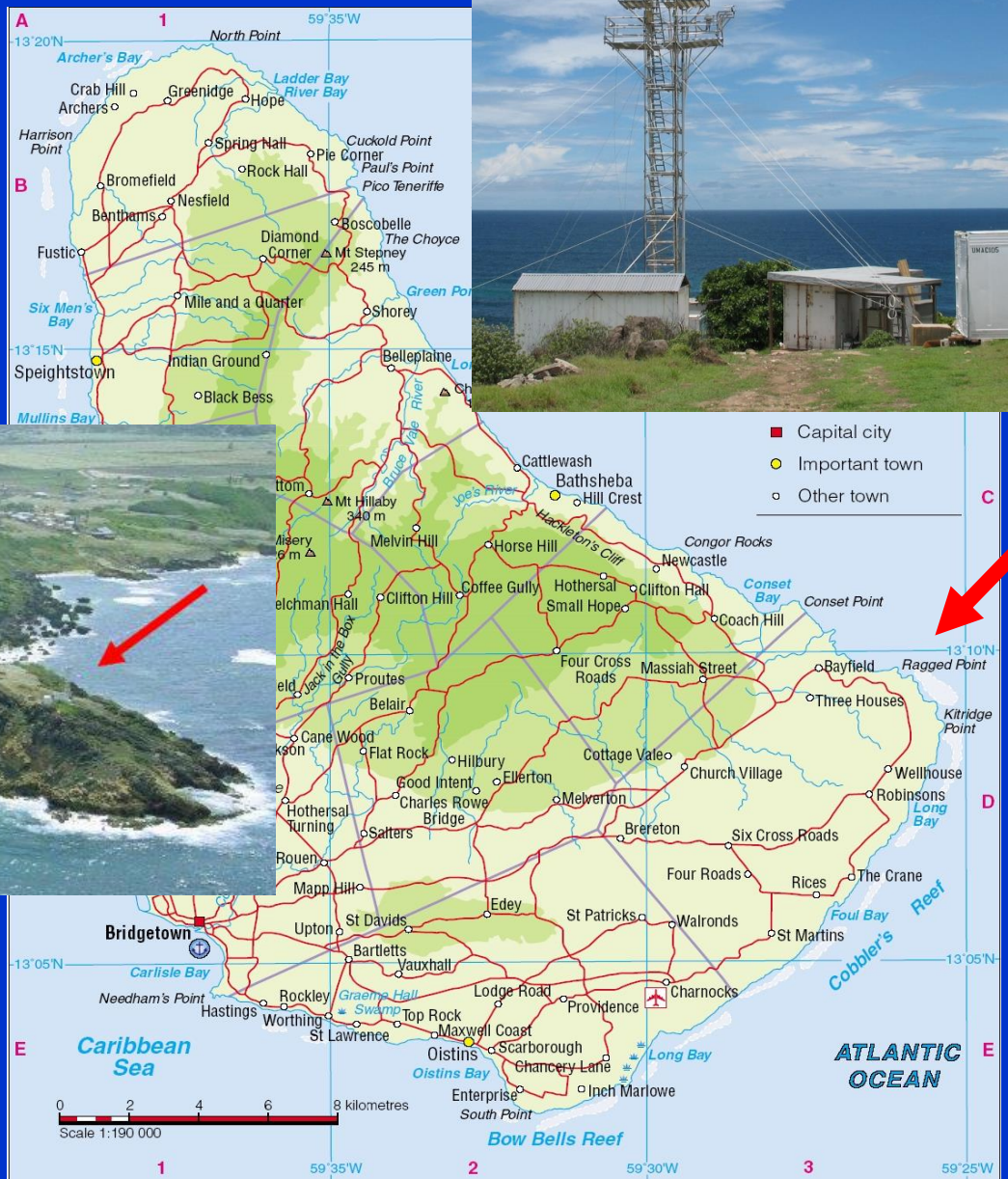
Hsu et al., 2010

Strong Transport to Caribbean - Summer; to South America – Winter & Spring

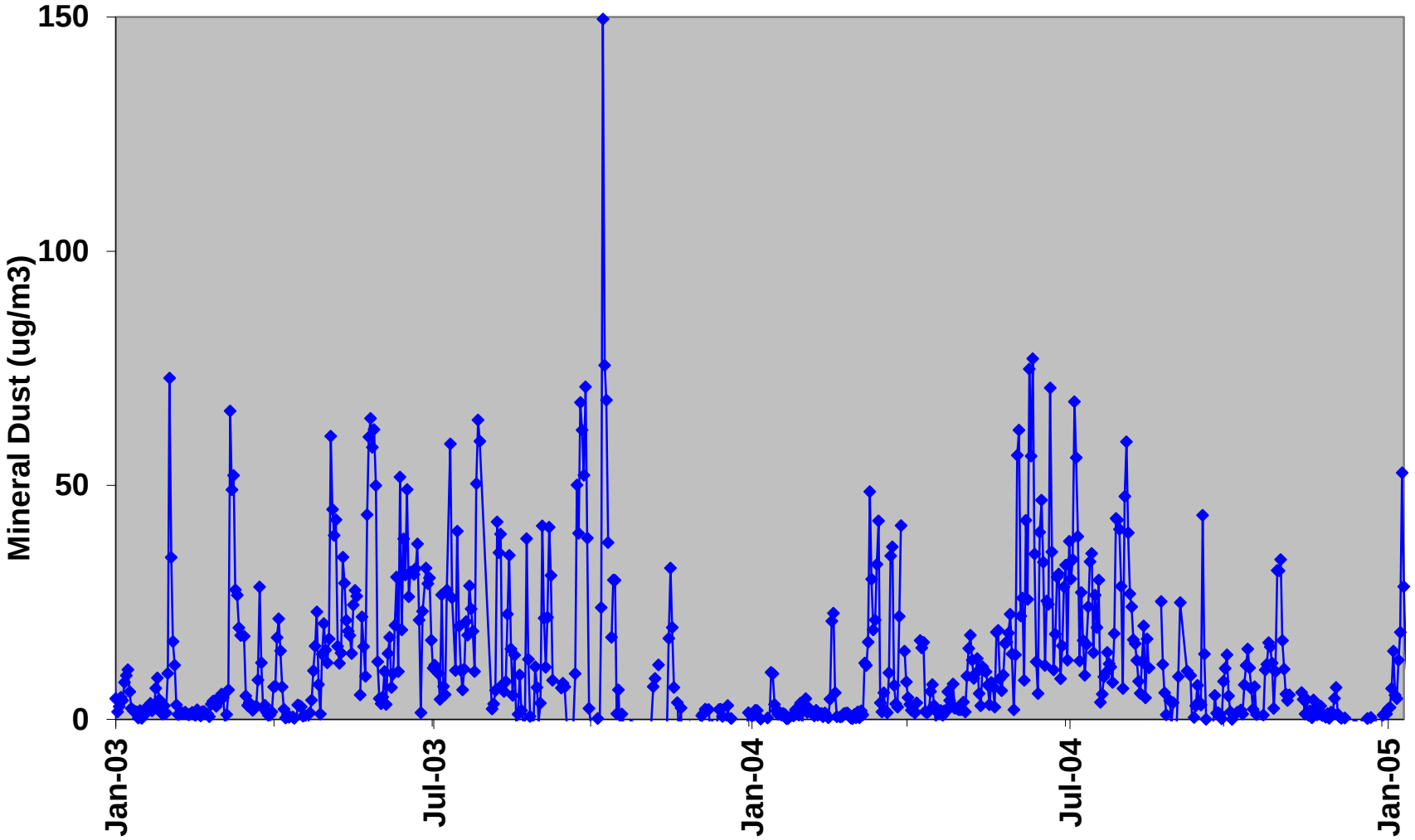
Our Sampling Network

U. Miami Aerosol Research Station, Barbados: 1965-2013



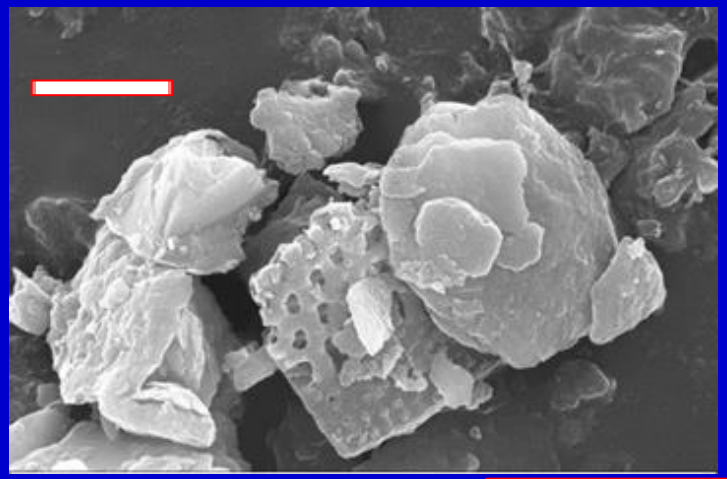


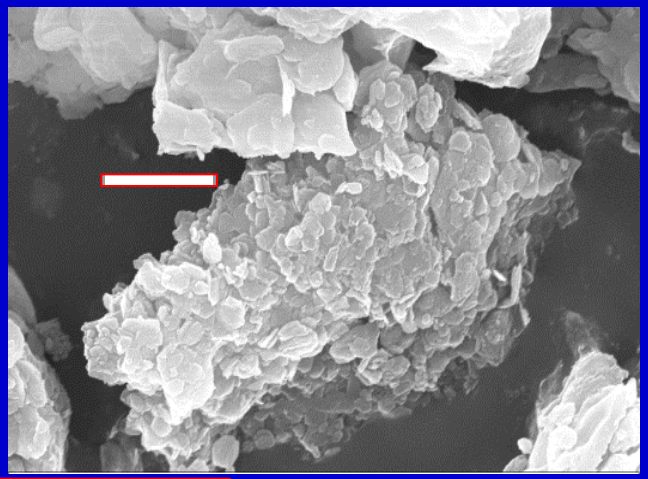
Daily dust variability Barbados : 2003 - 2004



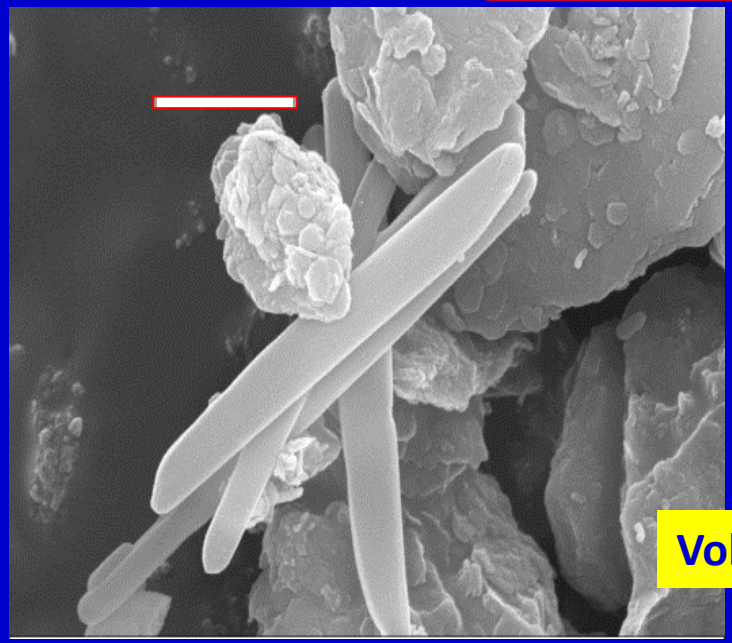
Seasonal changes are linked to changes in source activity and to large-scale changes in wind transport systems.

Dust Particle Morphology: Barbados





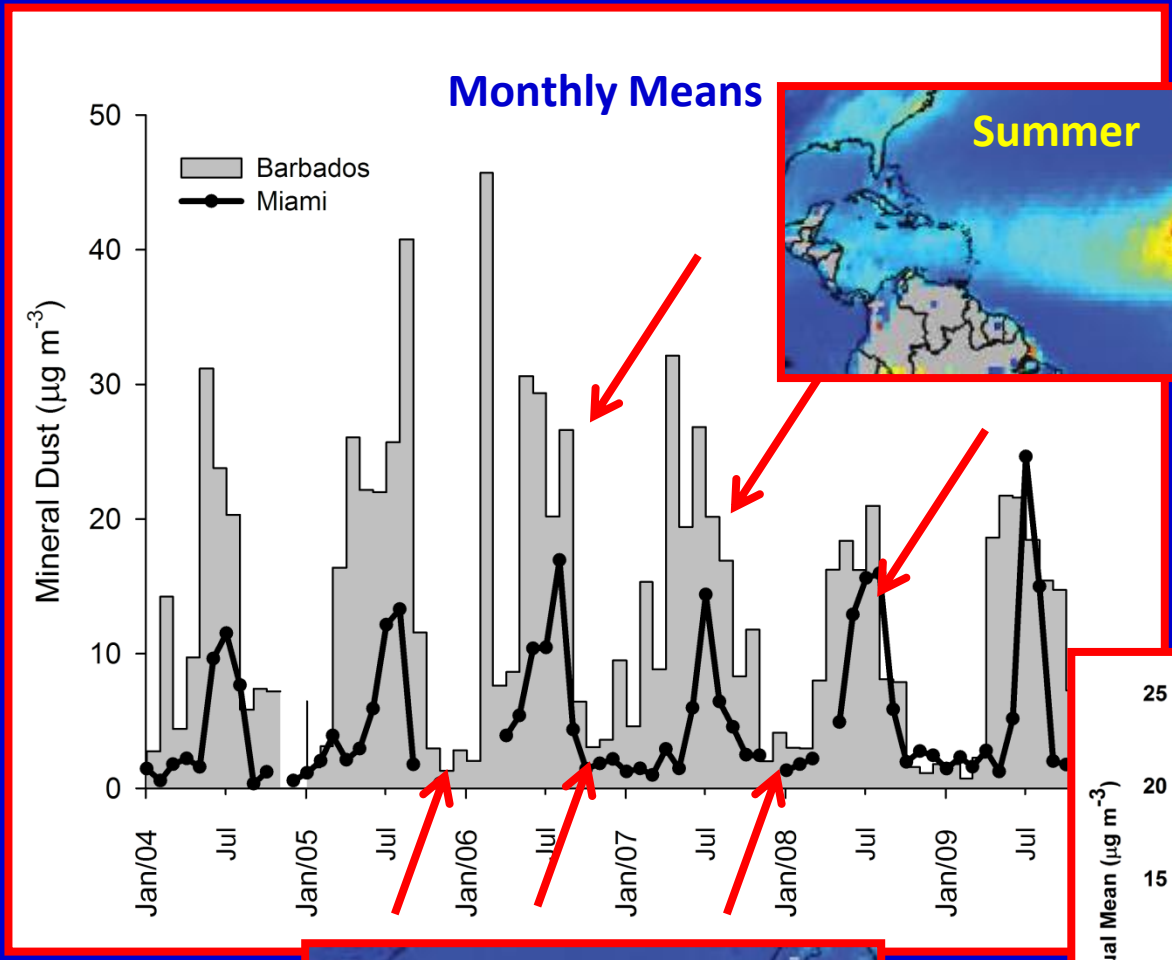
Scale bar = one micrometer.

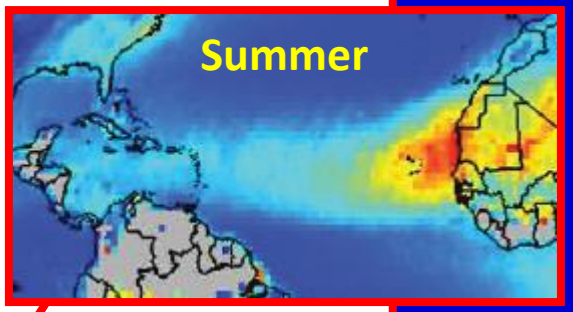


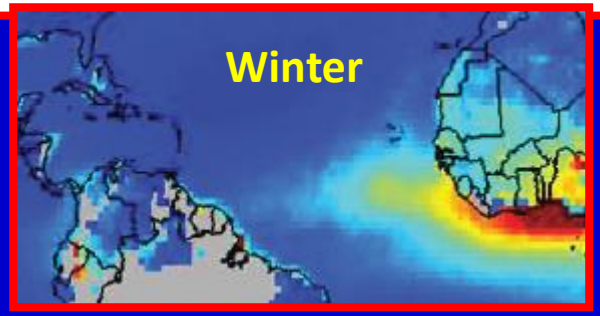
Scanning electron micrographs of aerosols collected on Barbados during dust outbreaks.

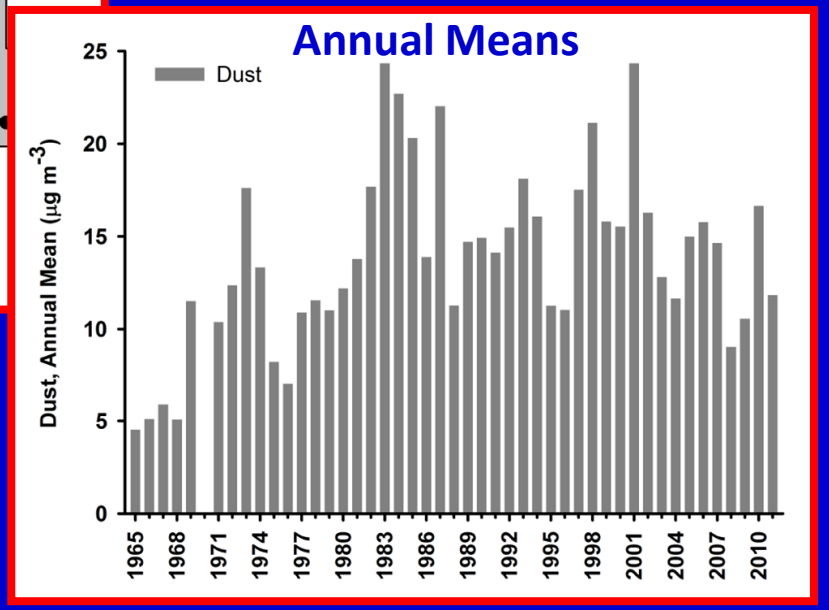
Volume median diameter about 2-3 um.

Strong Seasonal & Climate Control on Dust Throughout Caribbean

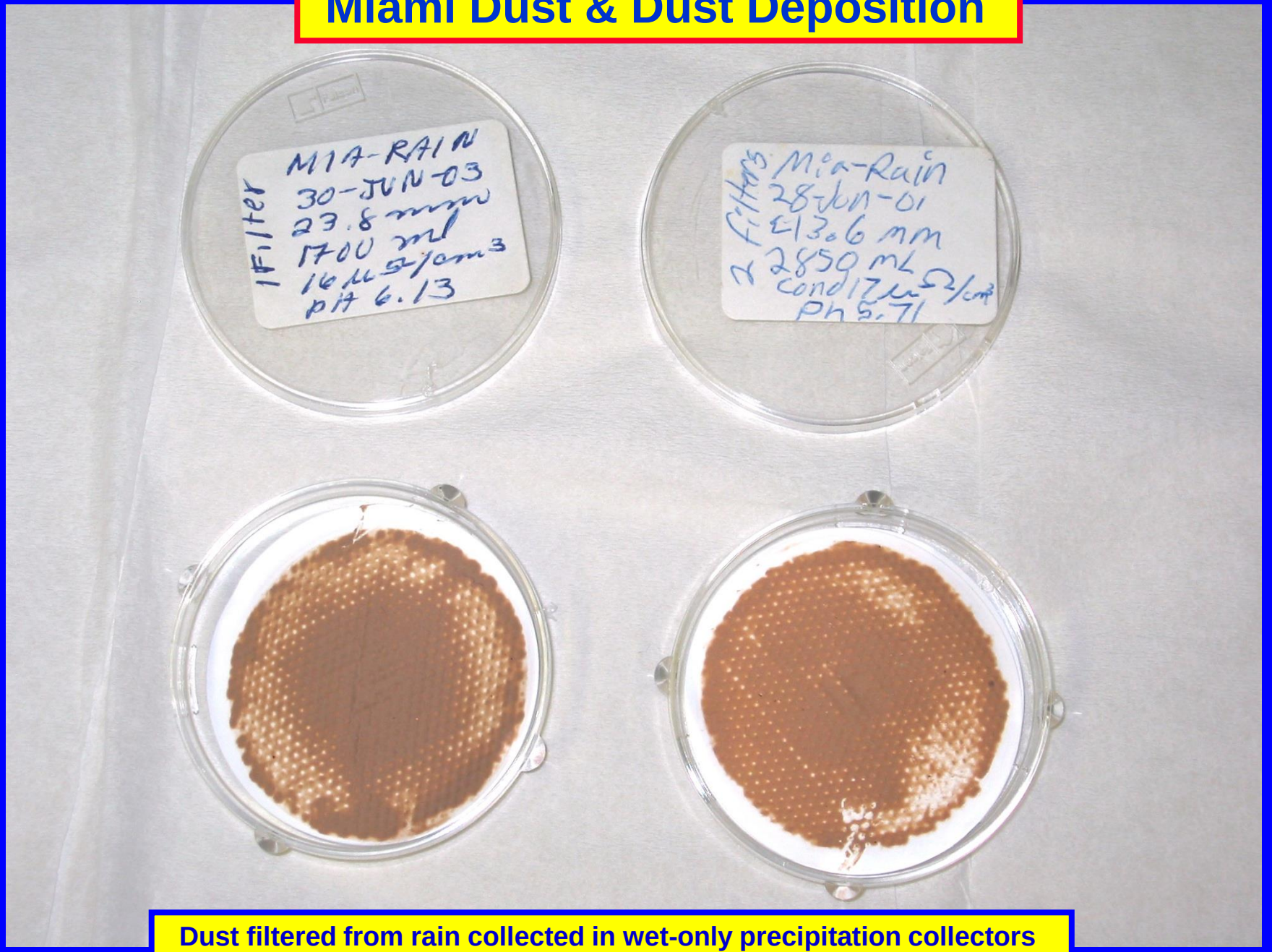








Miami Dust & Dust Deposition

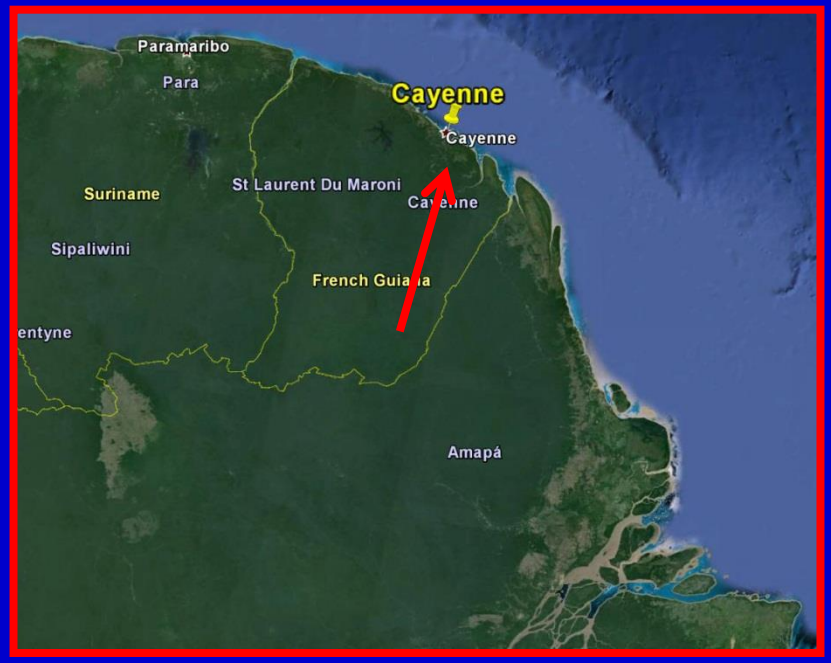


Dust filtered from rain collected in wet-only precipitation collectors

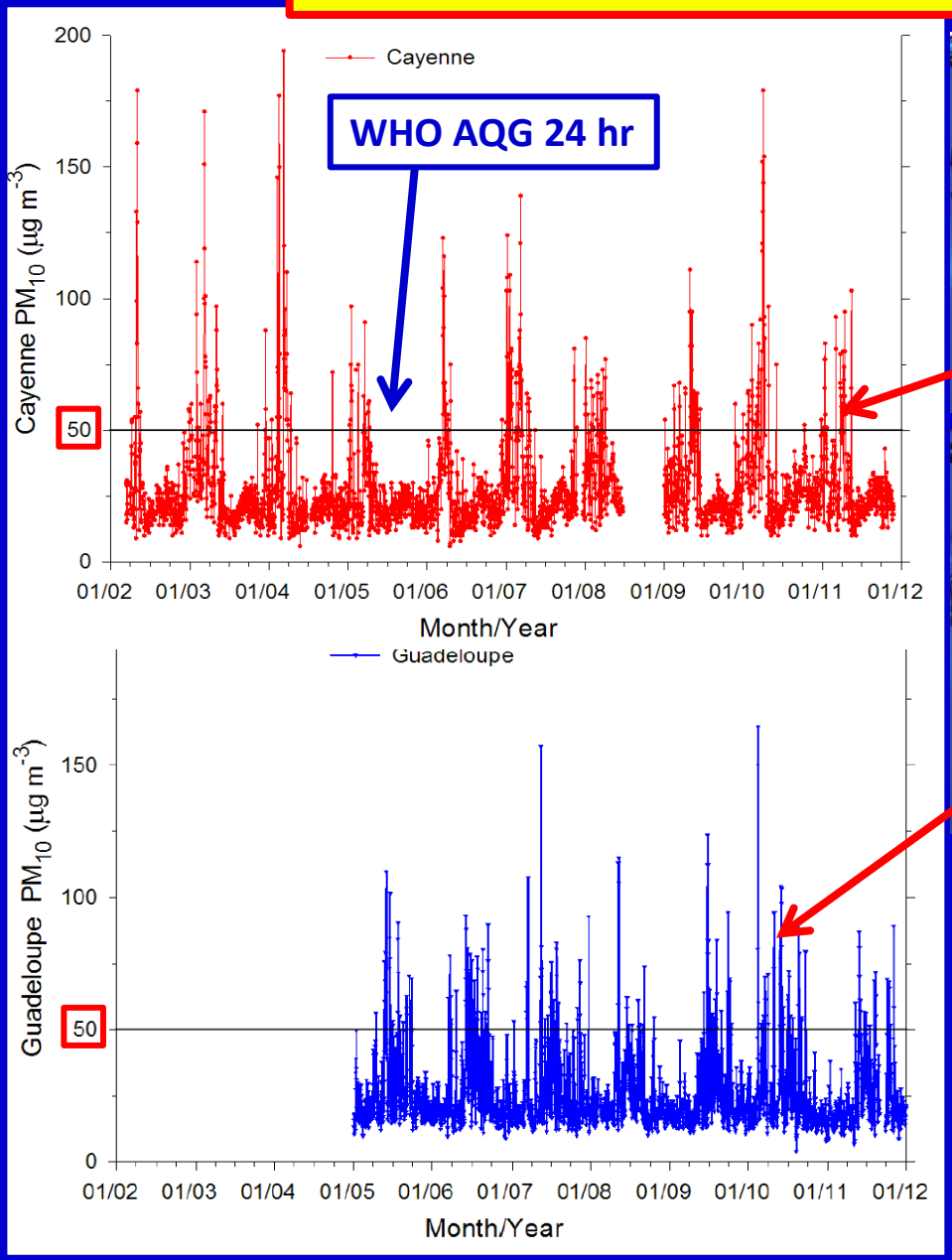
Joseph M. Prospero
RSMAS, Univ. of Miami

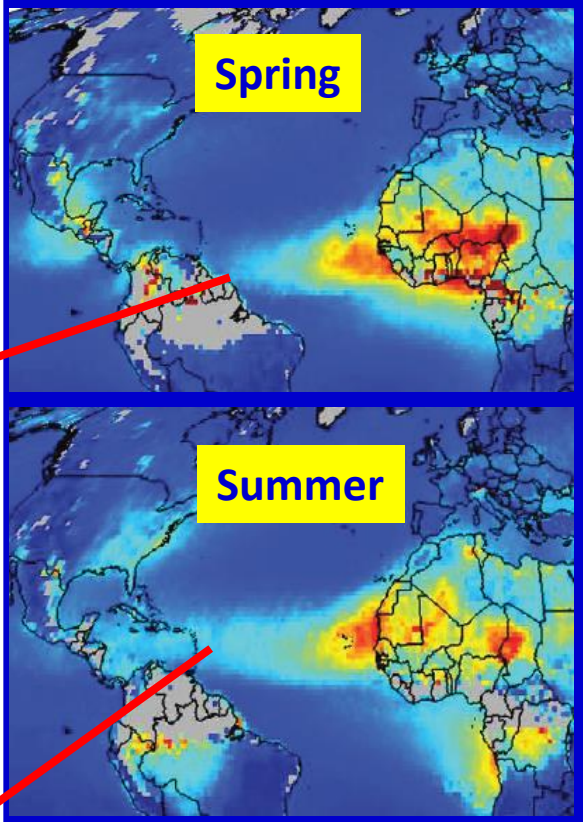
Guadeloupe & Cayenne: PM10 Measurements

- Sampling: under the French national air quality monitoring program.
- Aerosol concentrations (PM10 & PM2.5) measured with Thermo Scientific TEOM (Tapered Element Oscillating Microbalance) Model 1400.
- TEOM: qualified as a US EPA equivalent method for PM10 and PM2.5.



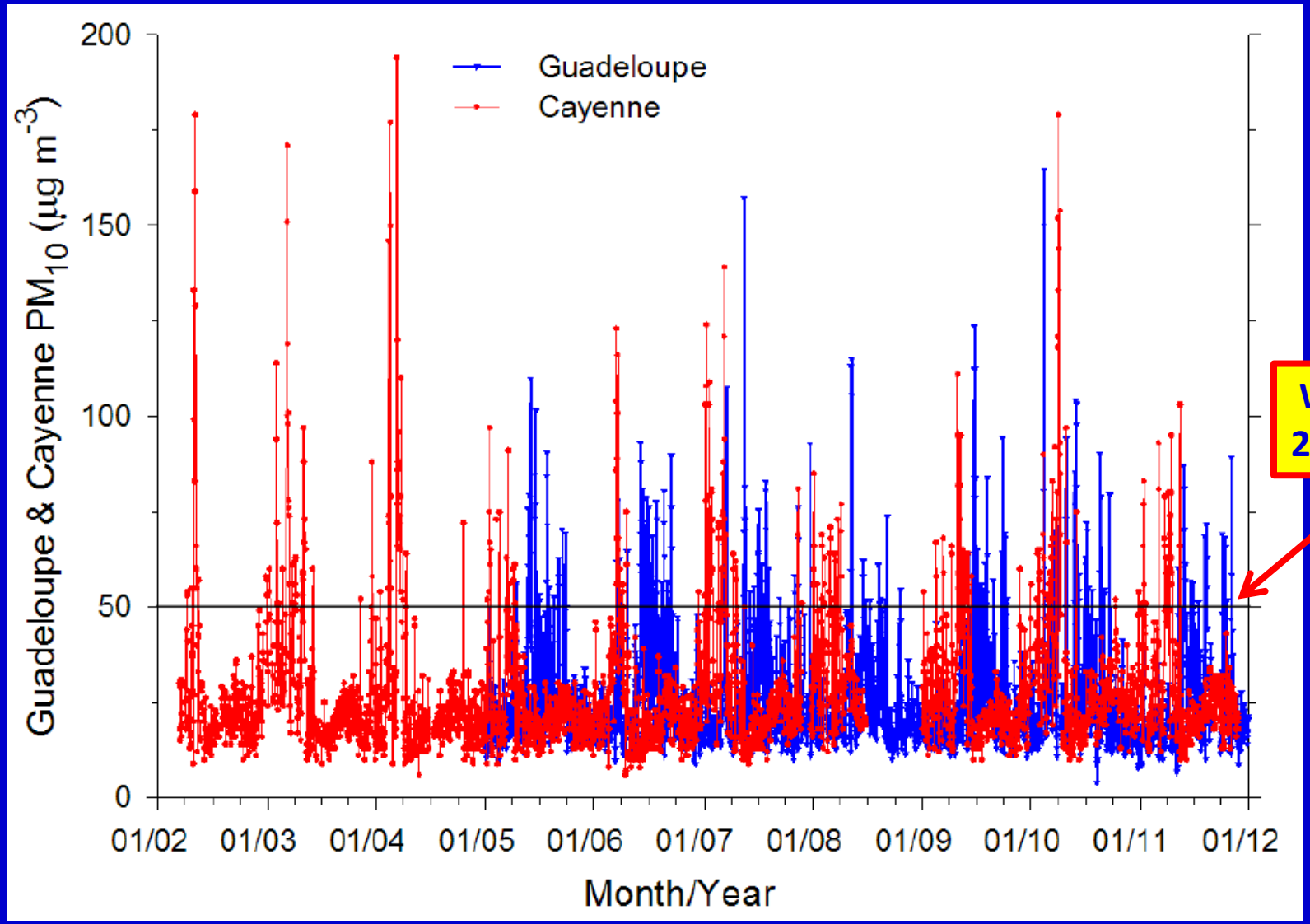
Daily PM10 at Cayenne and Guadeloupe



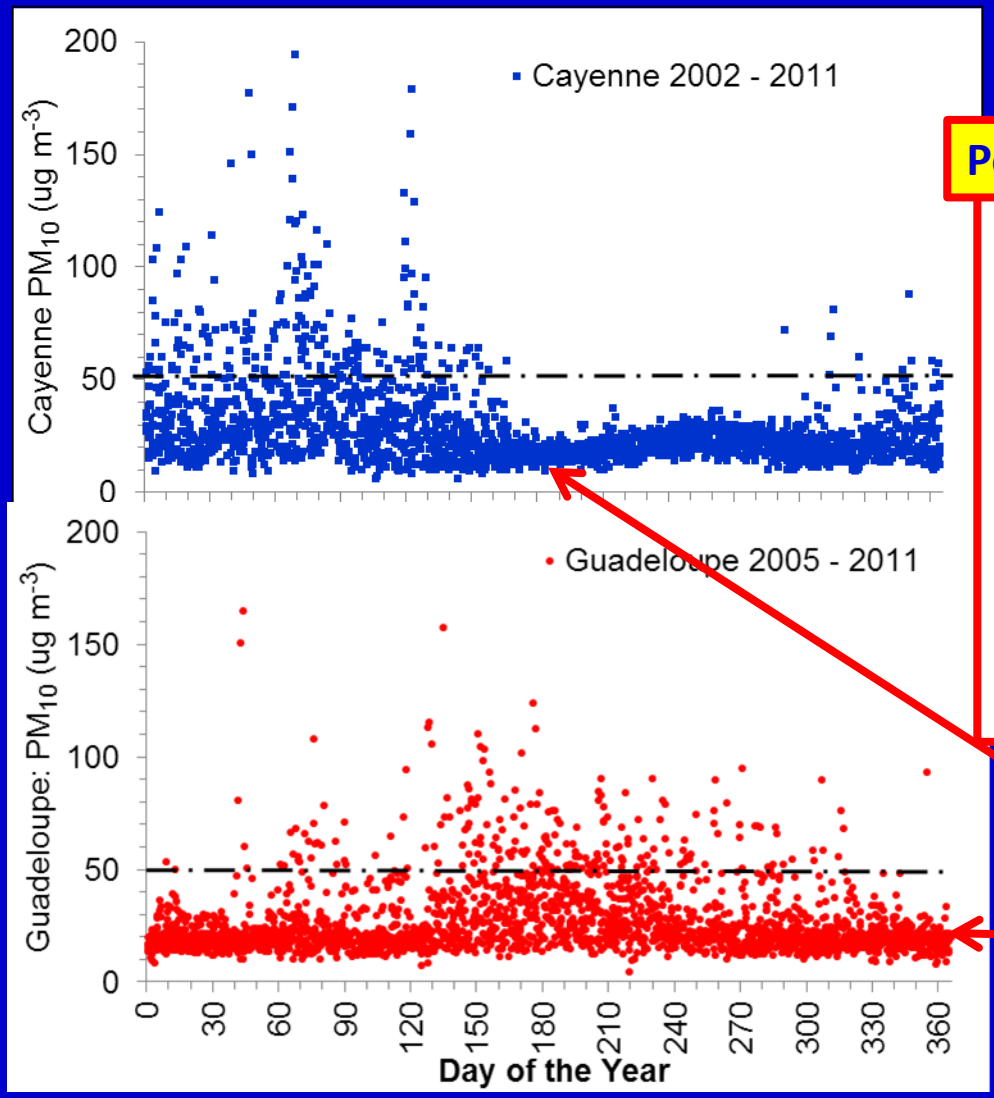


WHO Air Quality and Health
Fact sheet N°313 (Sep 2011)
Guideline values PM_{10}
20 µg/m³ annual mean
50 µg/m³ 24-hour mean

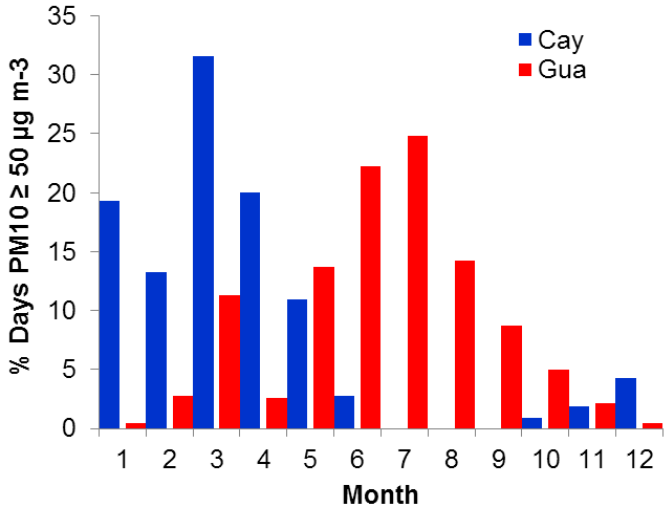
Daily PM10 at Cayenne and Guadeloupe



PM10: Day-of-the-Year Concentration Distribution

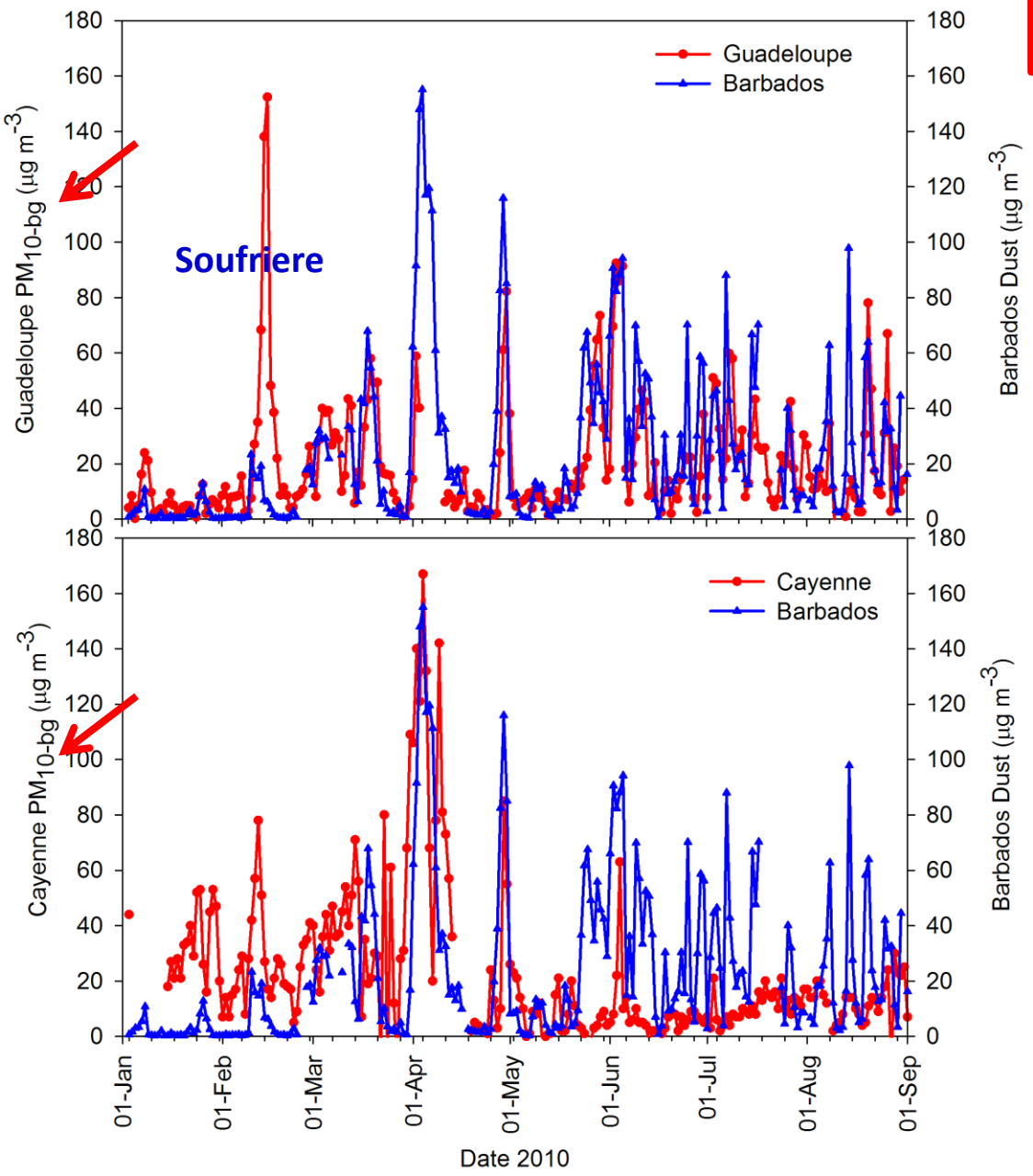


Percent of Days Exceeding 50 µg m^{-3}



"Background"
Lower bound ~ 12 µg m^{-3}

How much dust in PM10?



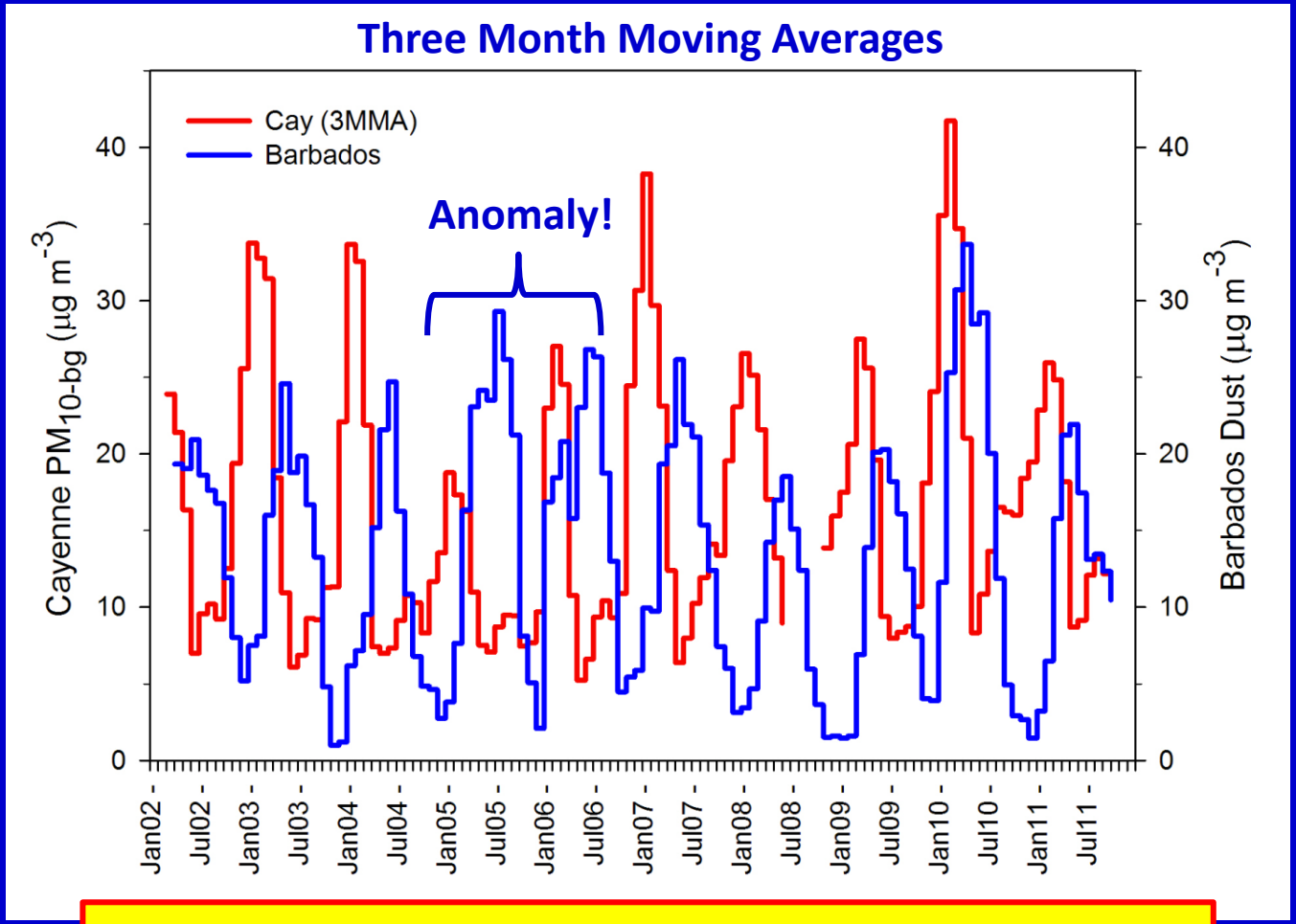
Compare daily PM10 with daily dust at Barbados.

Gua: March thru Summer
Gua ≈ Bar
i.e., PM10-bg ≈ Dust

Cay: March & April
Cay ≈ Bar
i.e., PM10-bg ≈ Dust

March and April: dust outbreaks impacted all three sites simultaneously at same concentrations, spanning 1400km latitude

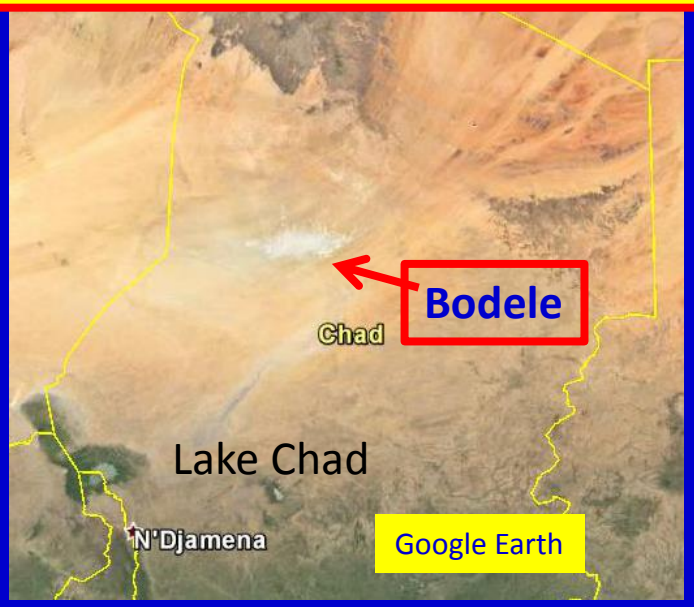
Cayenne PM10-bg & Barbados Dust: Seasonal Comparison



In most years, Cayenne $PM10_{-bg}$ exceeds Barbados dust!
Note strong anomaly in 2005 – 2006.

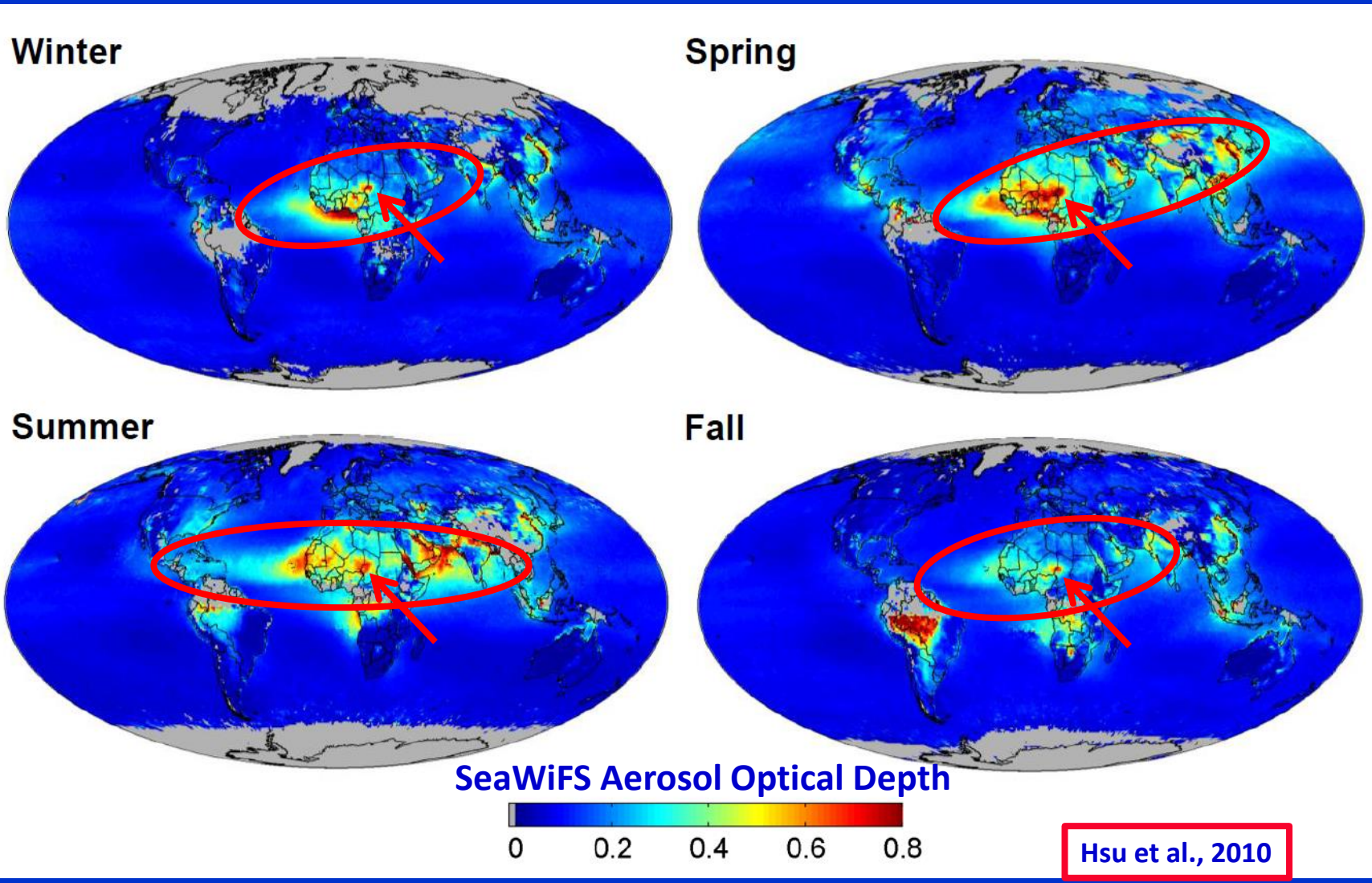
Major Source of Spring Dust at Cayenne: The Bodele Depression → the largest most persistently active dust source in the world.

Bodele Depression



MODIS: 06 January 2005

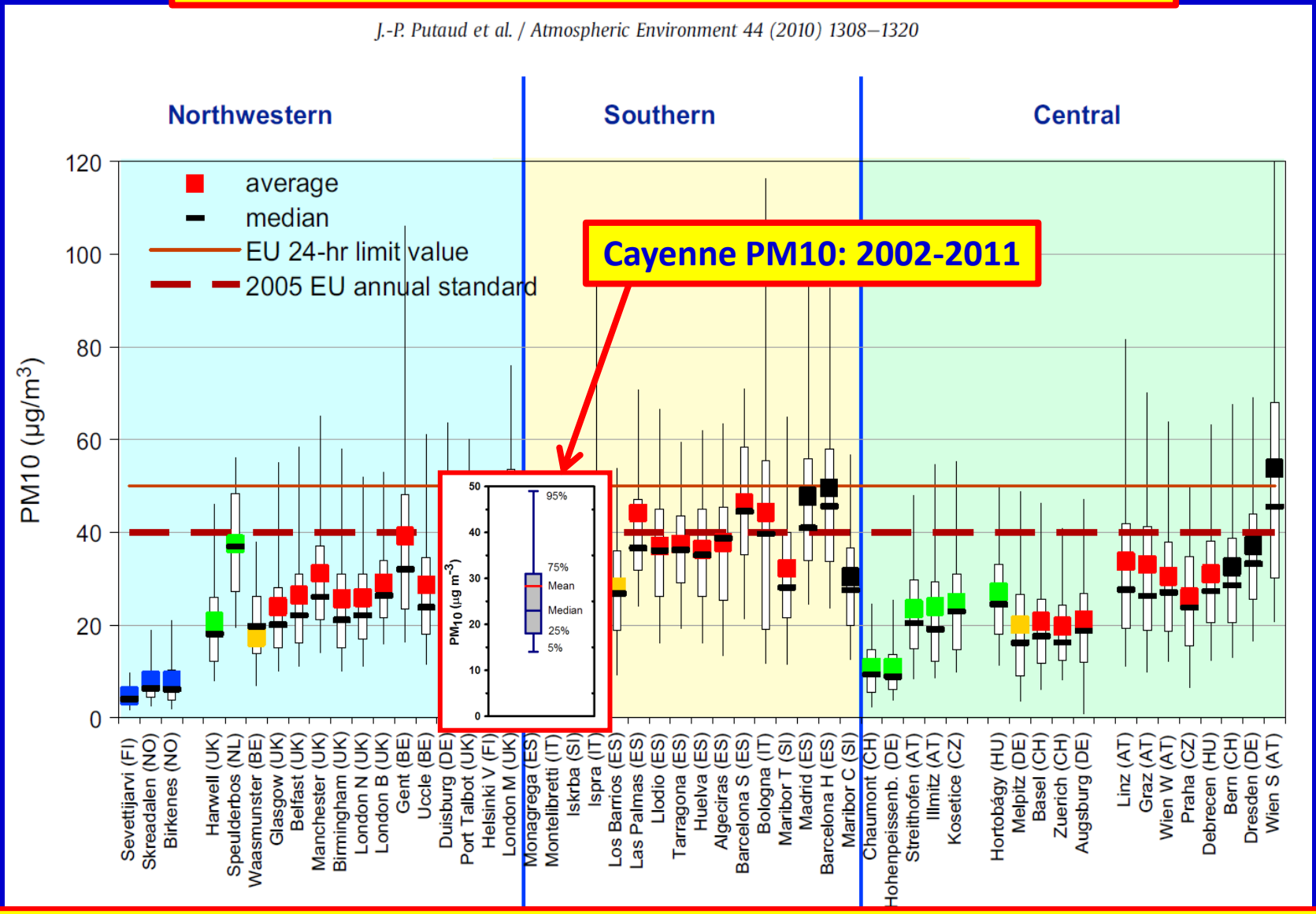
Global Distribution of Aerosols – The Bodele "Hot Spot"



Hsu et al., 2010

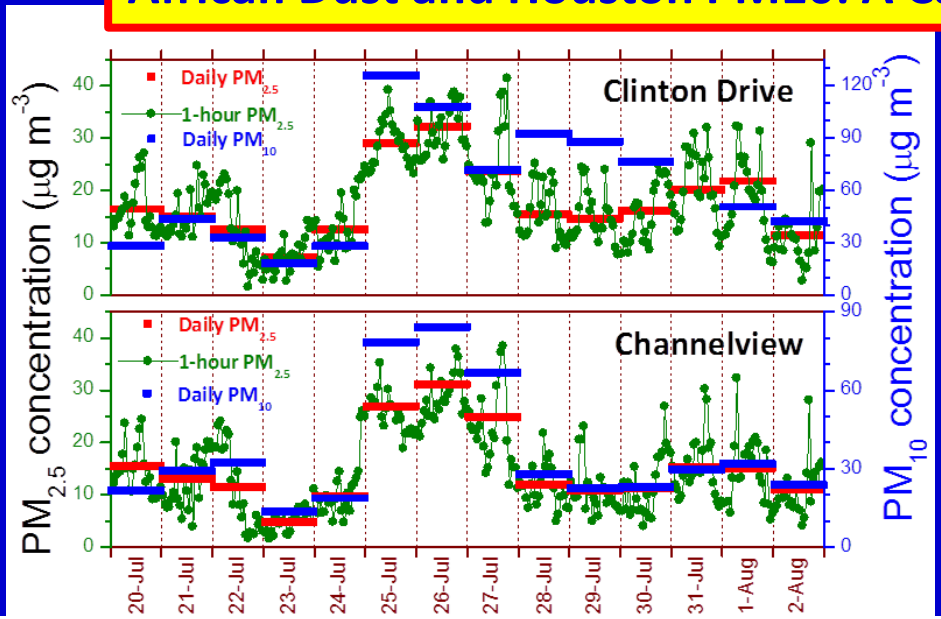
The Bodele dust source stands out all year long – but strongest in Spring.

Comparing Cayenne PM10 Statistics to Europe

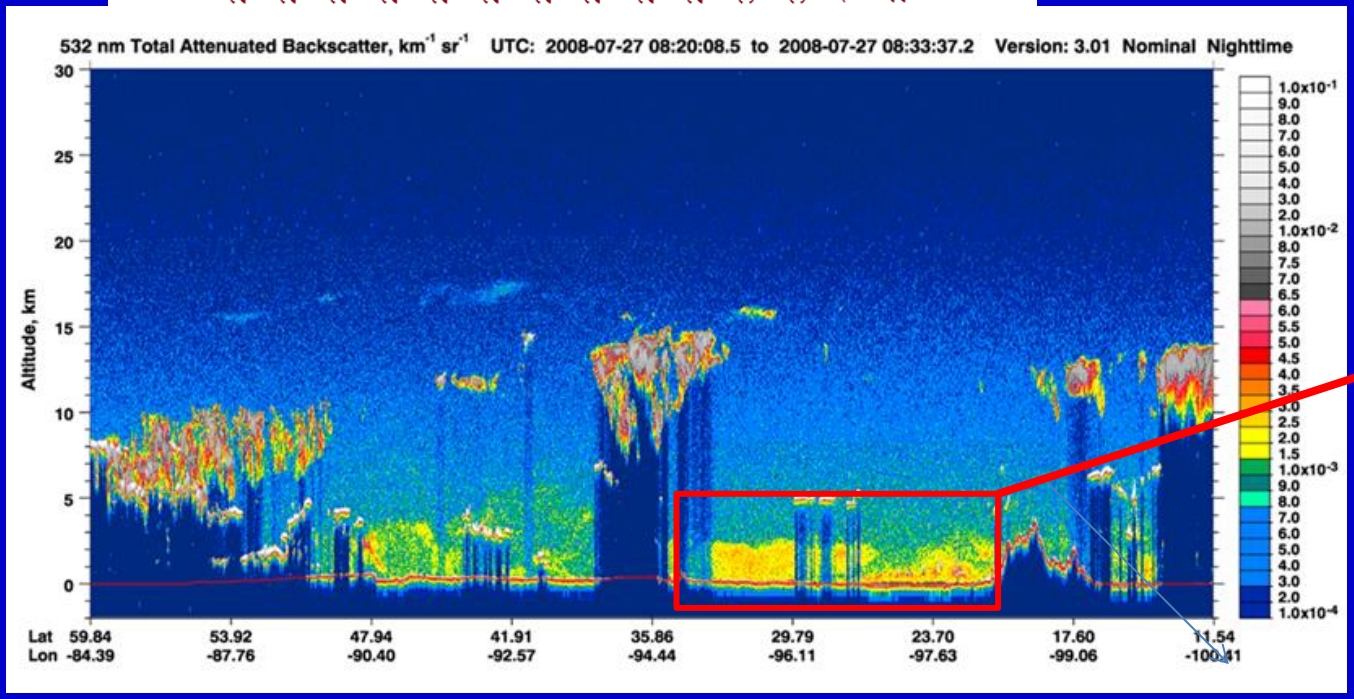


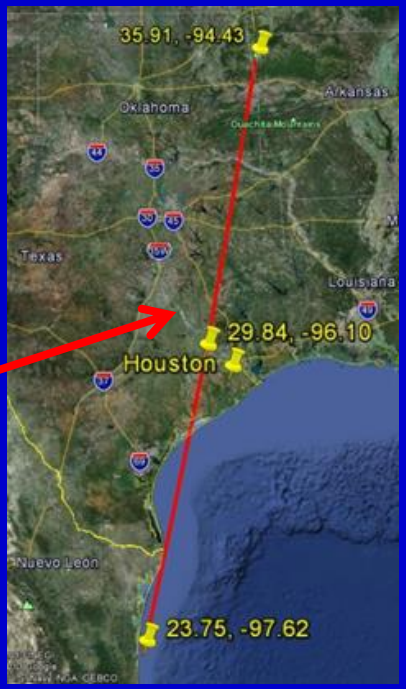
Annual averages of PM10 mass concentrations:, 25, 50 (median), 75, and 95% percentiles of 24-h concentrations. Colors: type of site (blue: natural background, green: rural background, yellow: near-city, **red: urban background**, grey: industrial, black: kerbside). **J.-P. Putaud et al. / Atmospheric Environment 44 (2010).**

African Dust and Houston PM10: A Case Study, July 2008



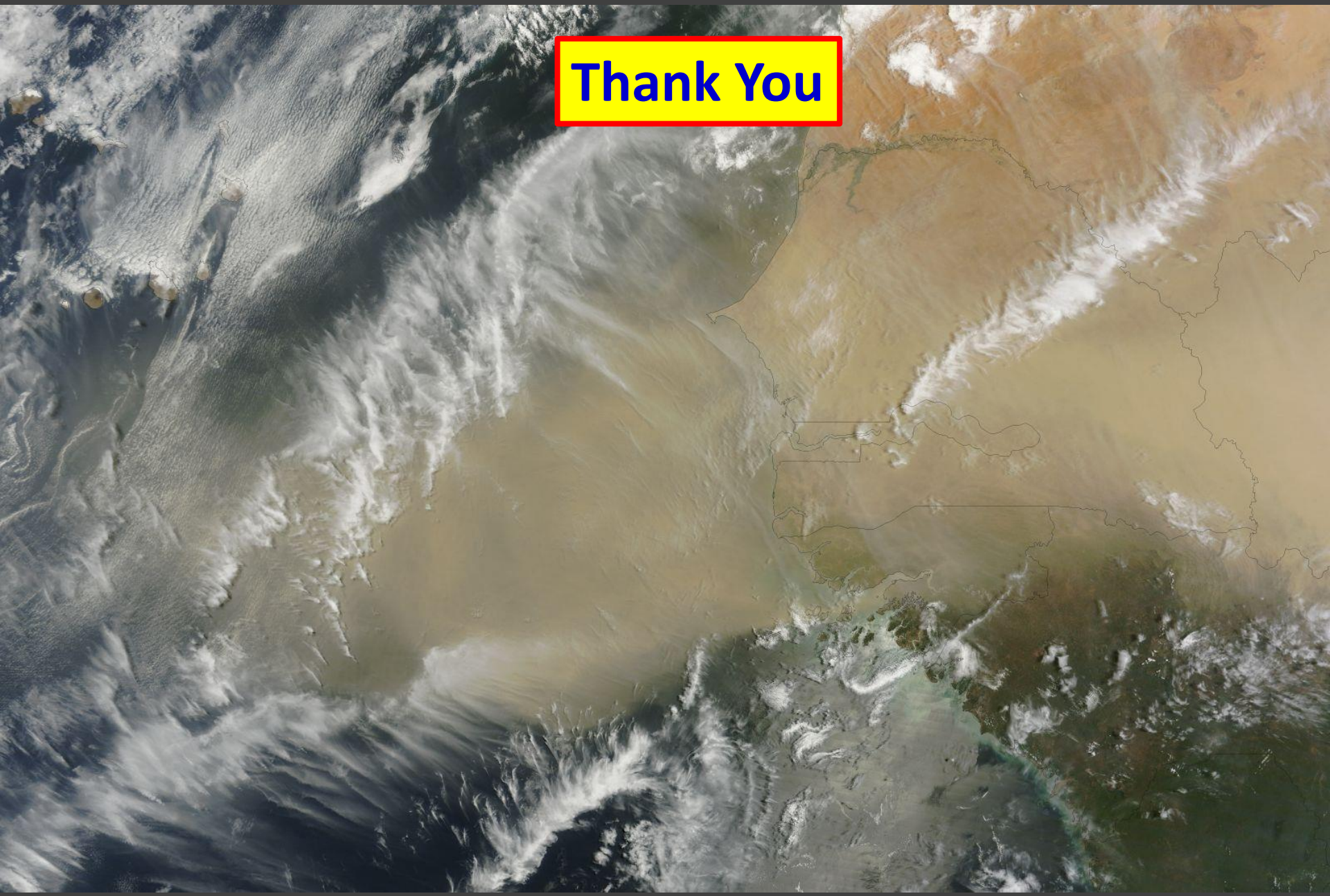
Quantifying the Contribution of Long-Range Saharan Dust Transport on Particulate Matter Concentrations in Houston, Texas, using Detailed Elemental Analysis.
Bozlaker, Prospero, Fraser, and Chellam, *Environ. Sci. Technol.*, 2013.



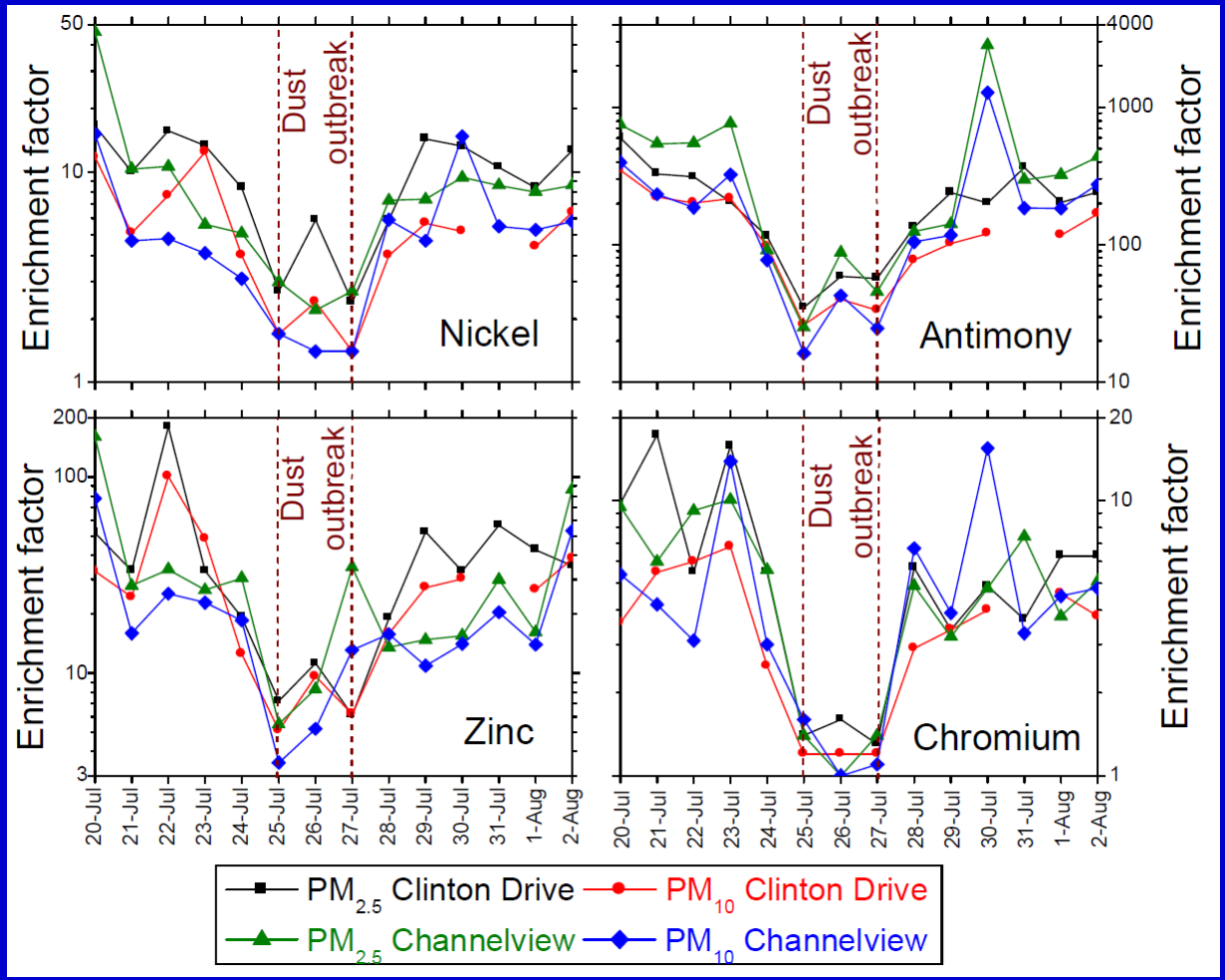


Conclusions

- PM 10 Concentrations in our study often exceed the WHO 24 hour AQG.
- PM10 exceedences are attributed to the presence of African dust.
  - Also true for Houston dust event.
- Our measurements are probably indicative of those over the entire Basin.
- The impact of this transport on human health is unknown.
- We might expect that the PM10 concentrations in this region will change with time as climate changes in Africa.


Thank You

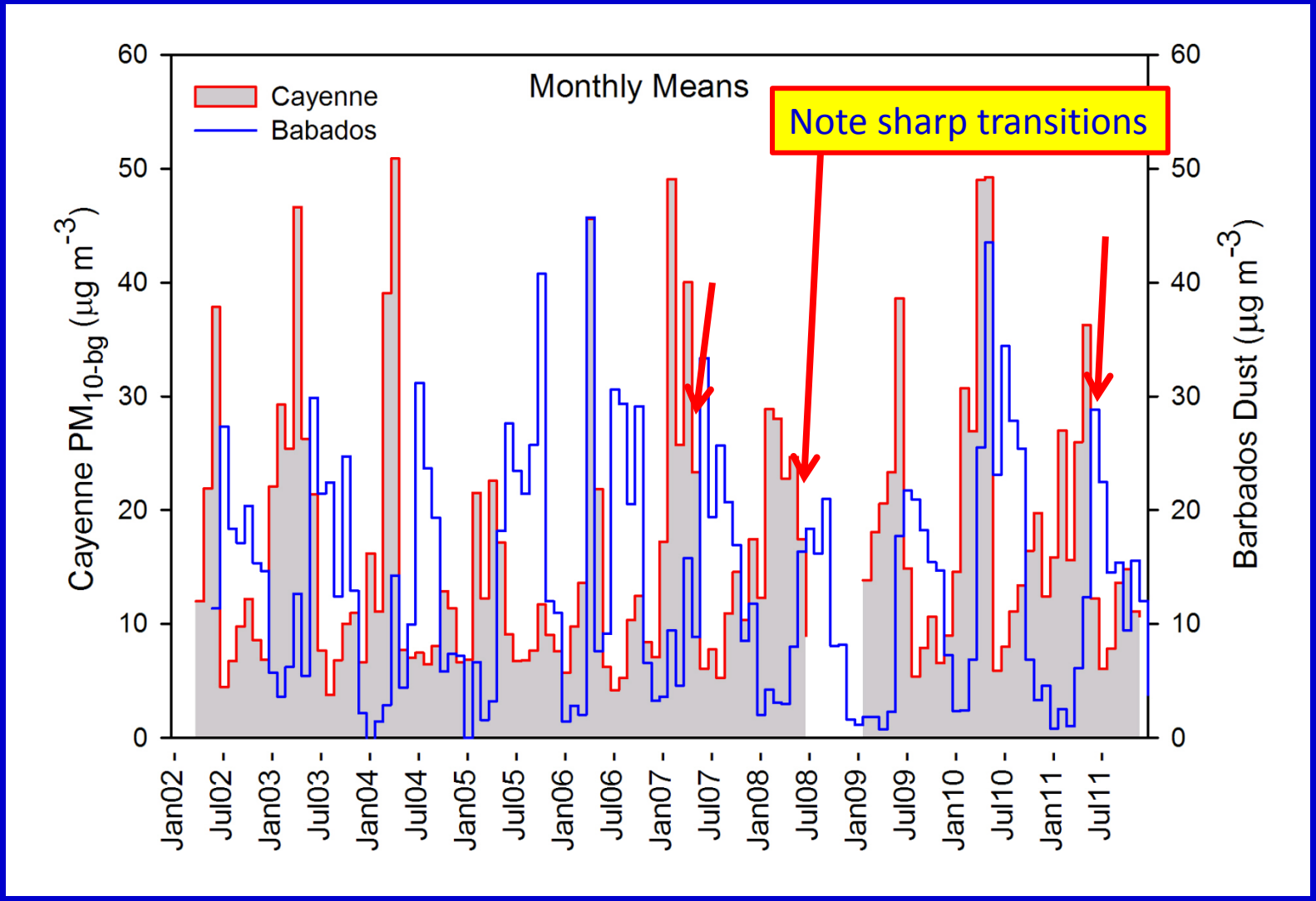
African Dust and Houston PM10: A Case Study, July 2008

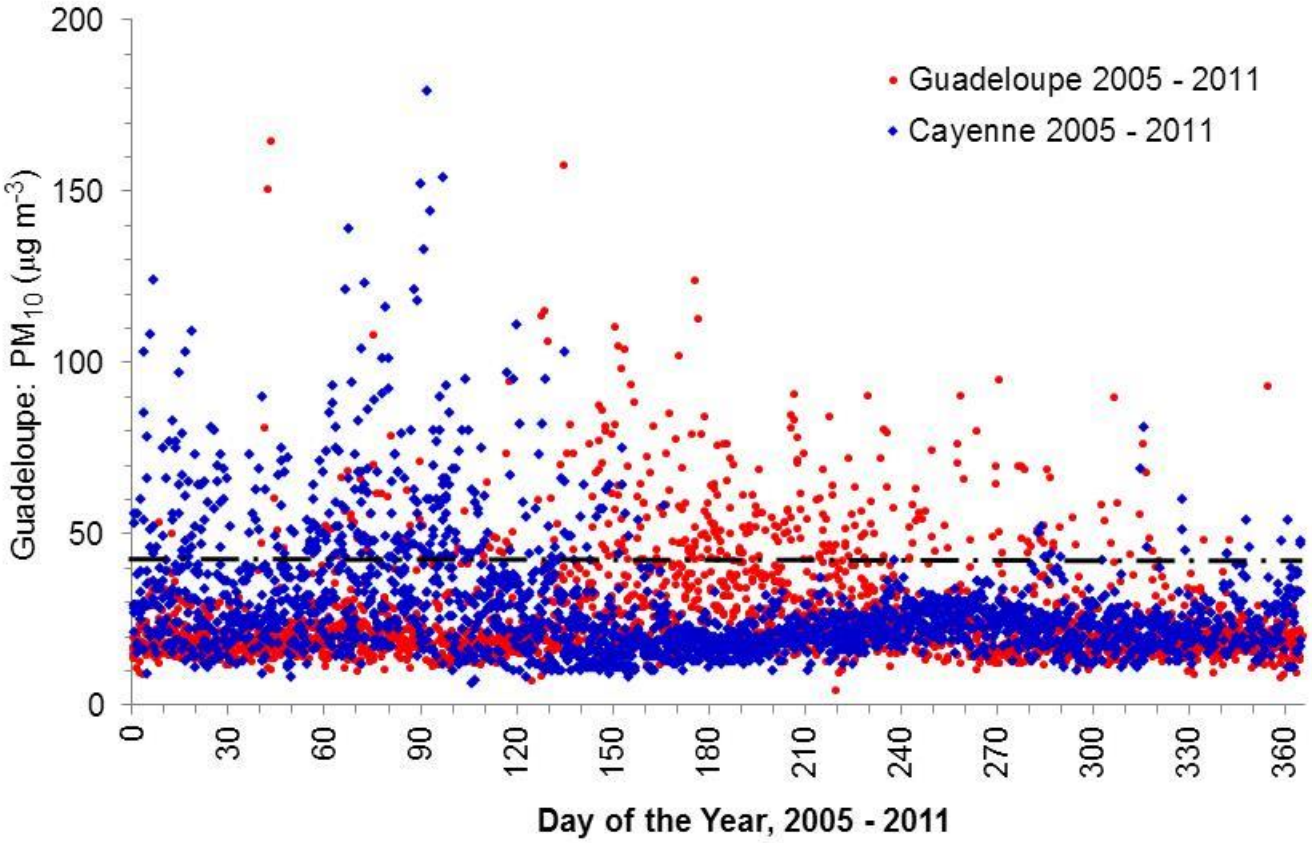


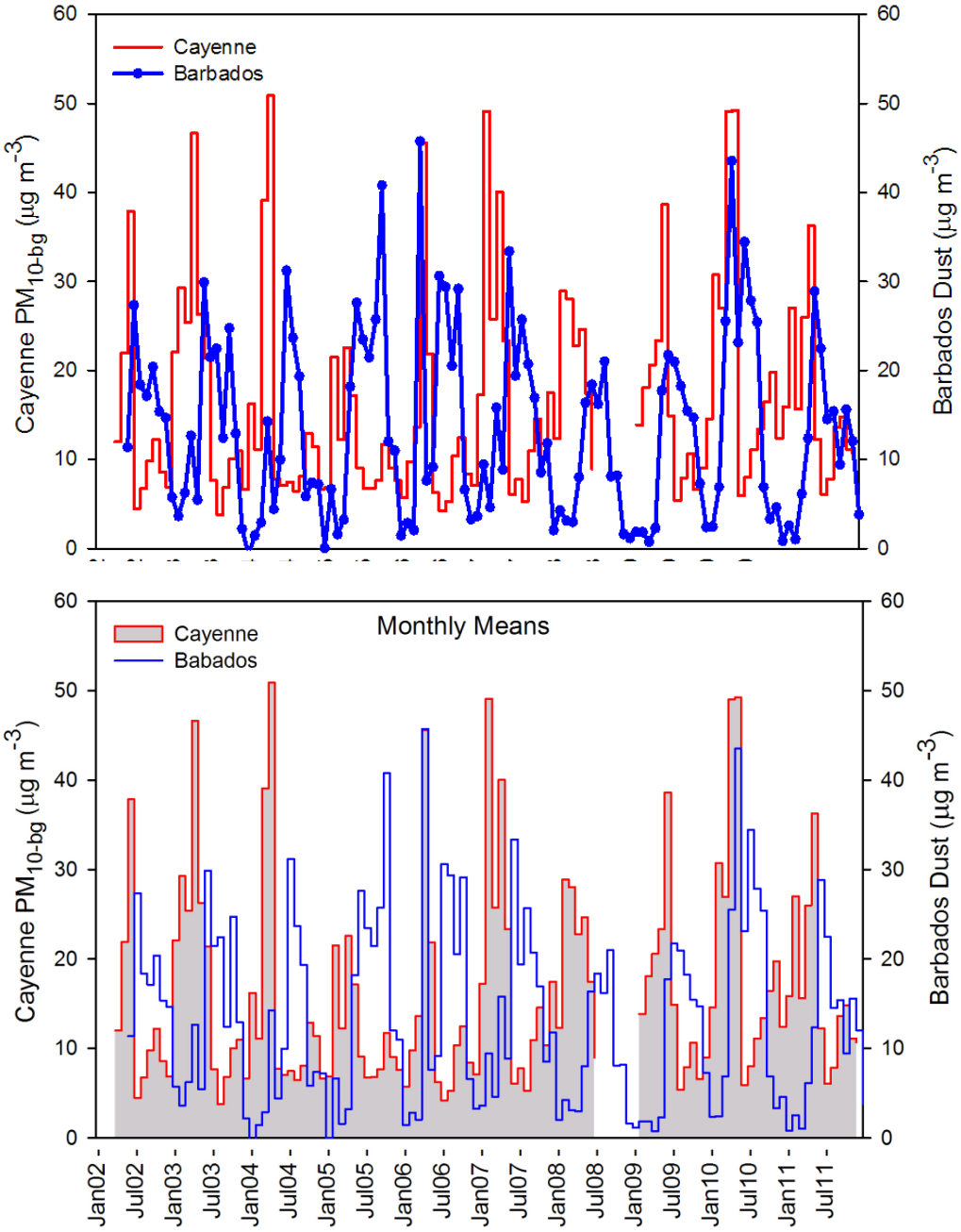
During the dust event, for most elements composition was quite similar to average crustal abundances, i.e., enrichment factors near one (except Sb!).

Bozlaker, Prospero, Fraser, and Chellam, 2013, *Environ. Sci. Technol.*

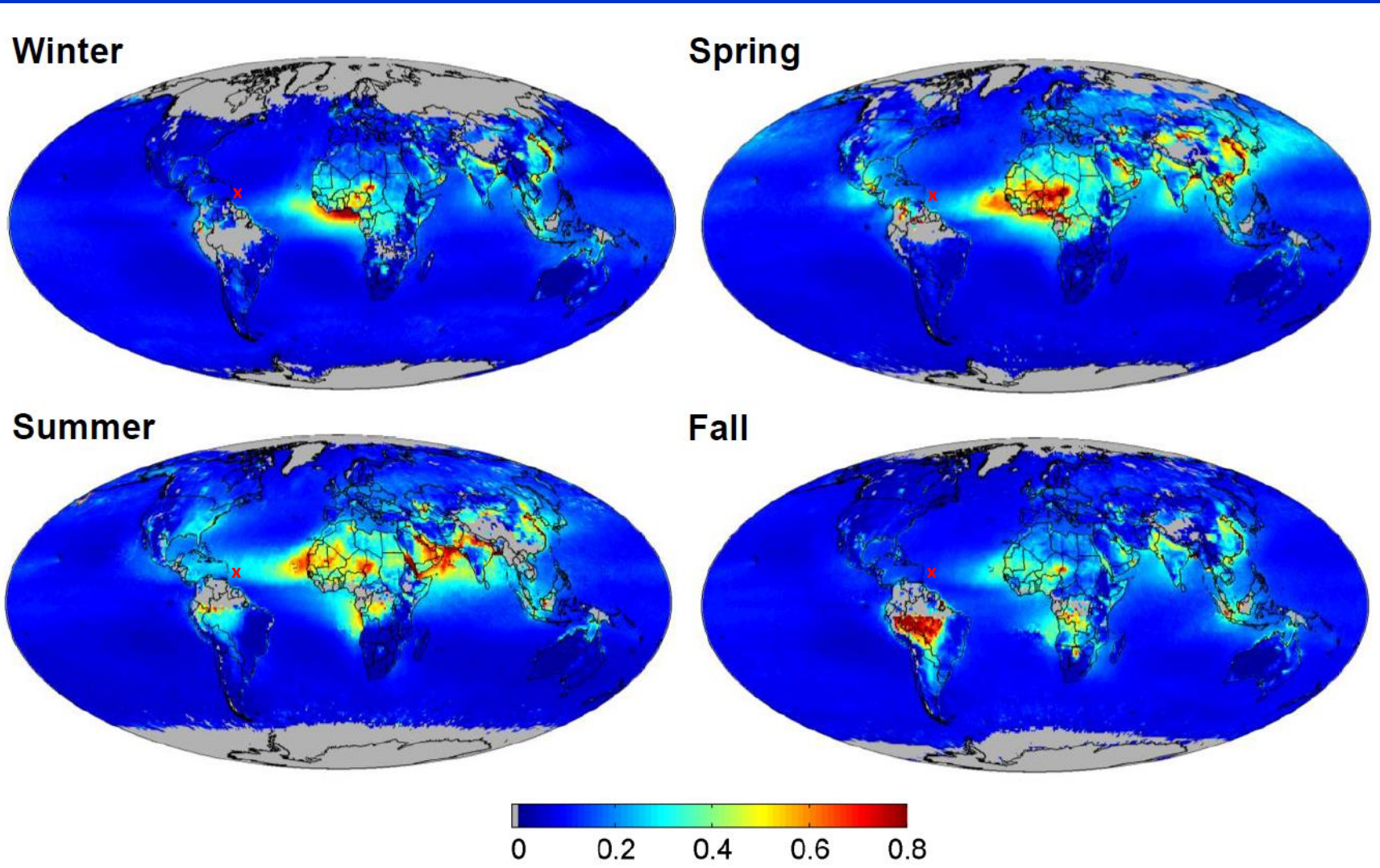
Comparing Monthly Mean $PM10_{-bg}$ at Cayenne with Barbados Dust




Guadeloupe 2005 - 2011
Cayenne 2005 - 2011
Guadeloupe: PM10 (µg m-3)
200
150
100
50
0
0
30
60
90
120
150
180
210
240
270
300
330
360
Day of the Year, 2005 - 2011

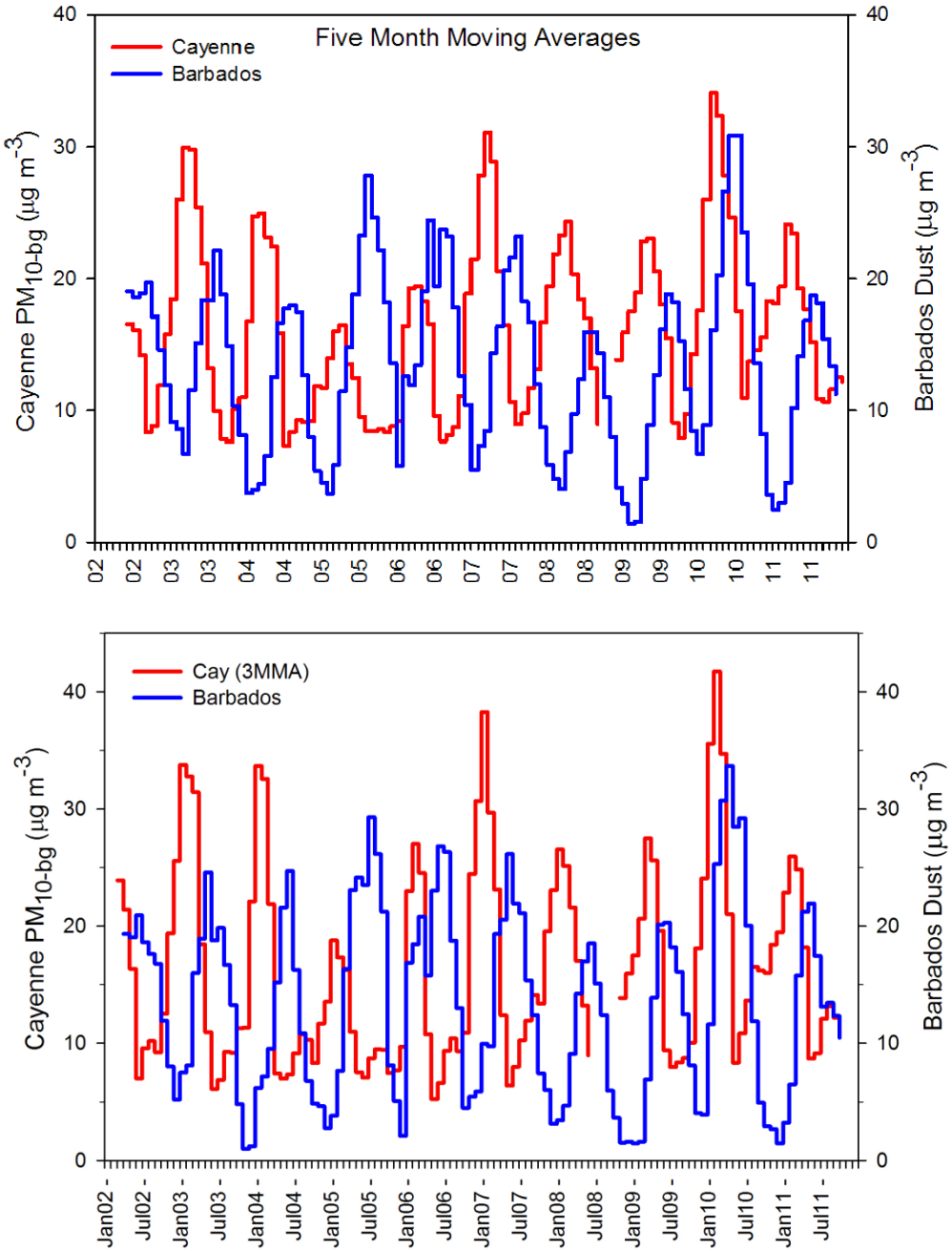

Cayenne
Barbados
Cayenne PM10-bg (µg m-3)
Barbados Dust (µg m-3)
Monthly Means
Cayenne
Babados
Jan02
Jul02
Jan03
Jul03
Jan04
Jul04
Jan05
Jul05
Jan06
Jul06
Jan07
Jul07
Jan08
Jul08
Jan09
Jul09
Jan10
Jul10
Jan11
Jul11

Satellites: Global Distribution of Aerosols – Dominance of Dust



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

Strong Transport to South America – Winter & Spring


Five Month Moving Averages
Cayenne
Barbados
Cay (3MMA)
Barbados
Cayenne PM10-bg (µg m-3)
Barbados Dust (µg m-3)
0
10
20
30
40
02
03
04
05
06
07
08
09
10
11
Jan02
Jul02
Jan03
Jul03
Jan04
Jul04
Jan05
Jul05
Jan06
Jul06
Jan07
Jul07
Jan08
Jul08
Jan09
Jul09
Jan10
Jul10
Jan11
Jul11

Cayenne and Guadeloupe:

- Sampling is carried out as part of the French air quality monitoring program.
- Aerosol concentrations (PM10 & PM2.5) are measured using the Thermo Scientific TEOM (Tapered Element Oscillating Microbalance) Model 1400.
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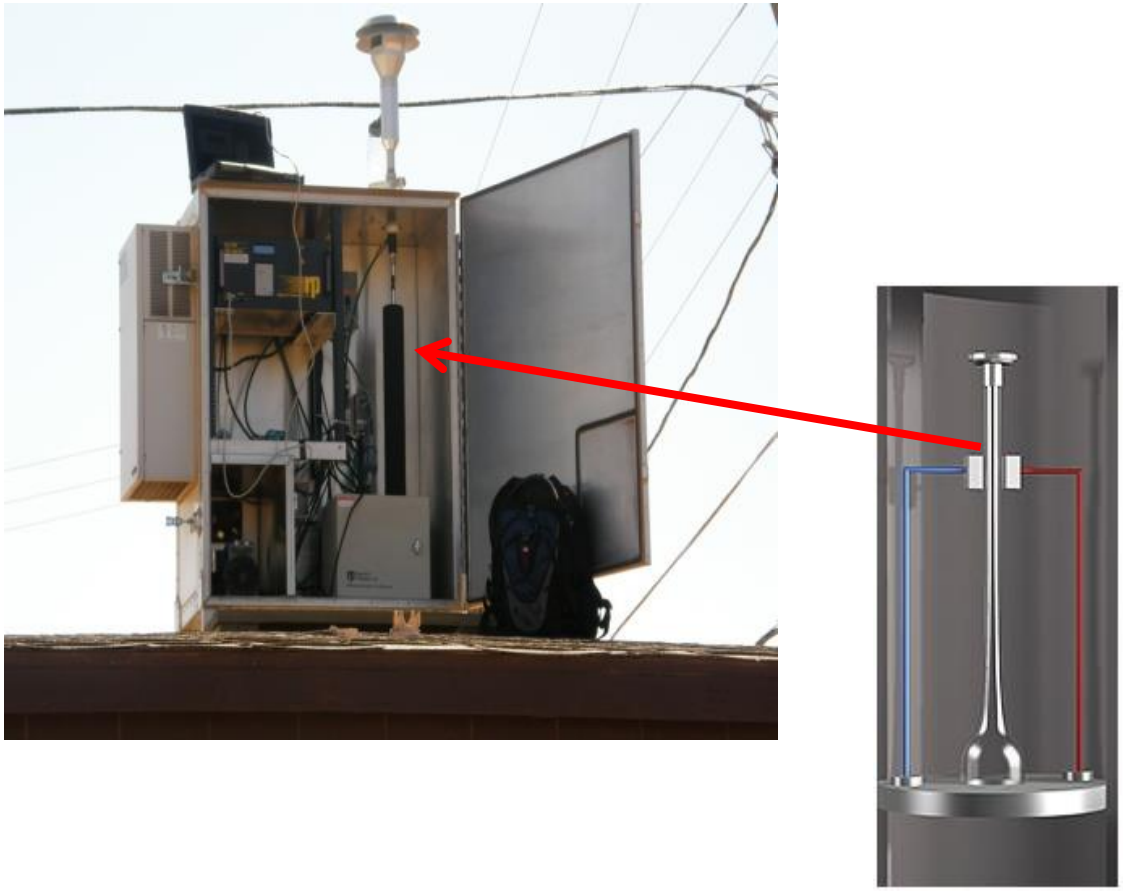
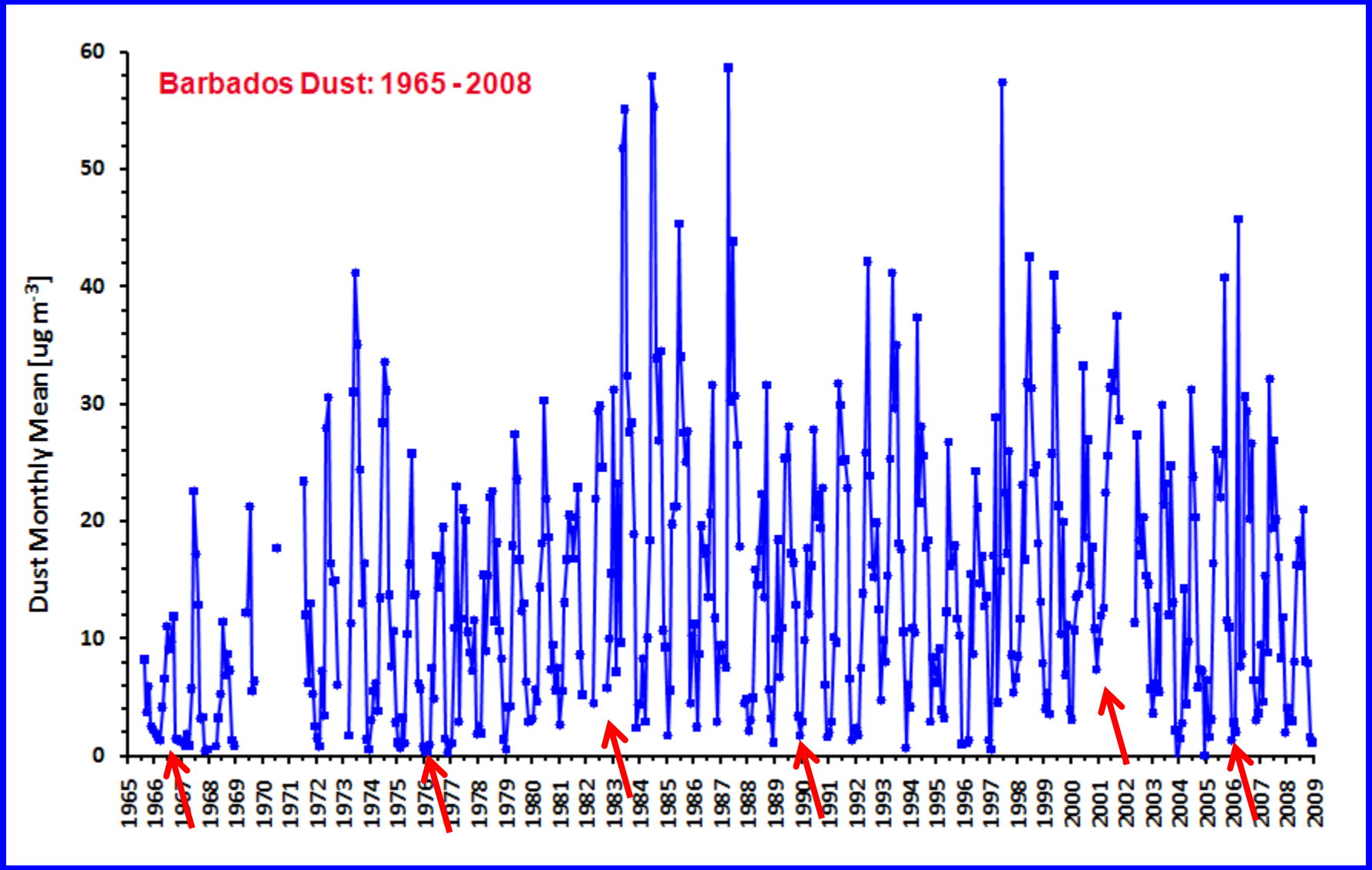


Long Term Variability of Barbados Dust: Monthly Means 1965 - 2008



Big changes in Summer dust. Note: Winter dust changes also!