Long-term climatology of giant dust storms for national climate assessment:

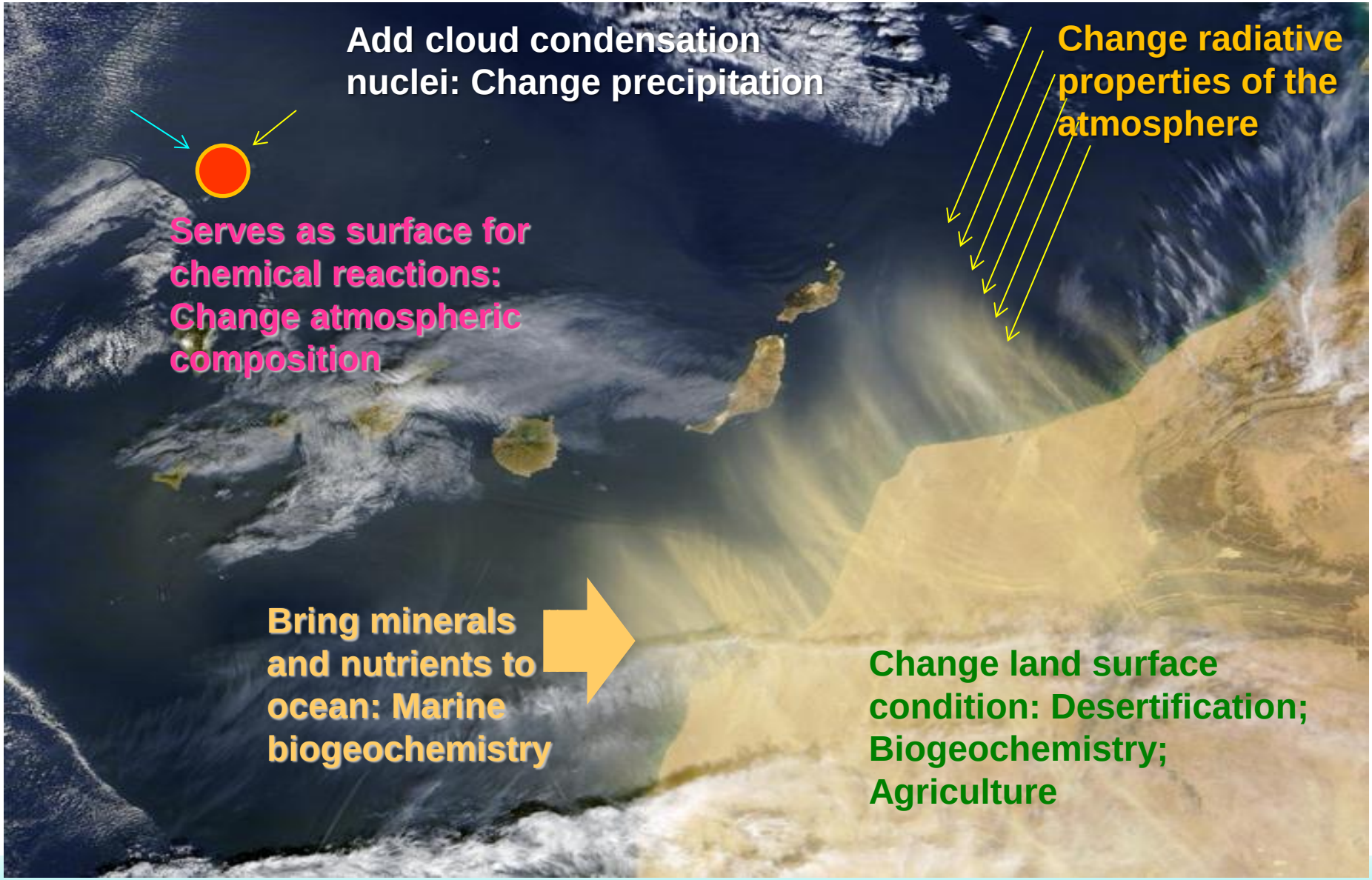
Will the U.S. see another "Dust Bowl" soon?

Daniel Tong[1,2], Hang Lei[1,2], Pius Lee[1] and Julian Wang[1]

1.NOAA Air Resources Laboratory, College Park, MD;
2.George Mason University, Fairfax, VA

(Picture Credit: blog.maricopanewhomes.net)

Climate effects of mineral dust



The “Dust Bowl”

- Dust Bowl: A period of severe dust storms during the 1930s;
- Causes: Extended droughts and poor land management;
- Impacts:
  - ✓ Stripped 75% of top soils over thousands of farms;
  - ✓ Destroyed agriculture and ecosystem (~1950s);
  - ✓ 400,000 – 2.5 millions lost homes and communities;

"And then the dispossessed were drawn west--from Kansas, Oklahoma, Texas, New Mexico; from Nevada and Arkansas, families, tribes, dusted out, tractored out... They streamed over the mountains, hungry and restless--restless as ants, scurrying to find work … anything, any burden to bear, for food. The kids are hungry. We got no place to live…”

-- John Steinbeck in the Grapes of Wrath

Will US see another Dust Bowl?

- Reconstructed paleoclimatic records - the central U.S. plains saw severe droughts about once or twice a century over the past 400 years (Woodhouse and Overpeck, 1998).

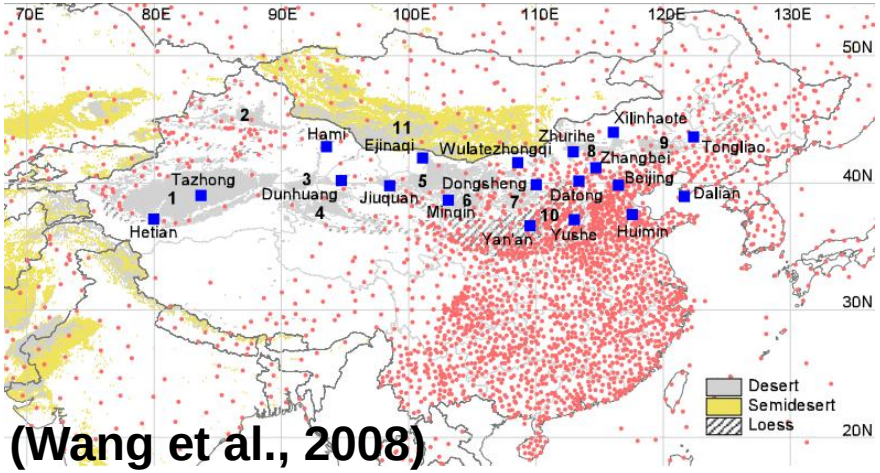
- This recurring trend may be enhanced global climate change (Schubert et al., 2004).

- There is no long-term dust climatology in the US.

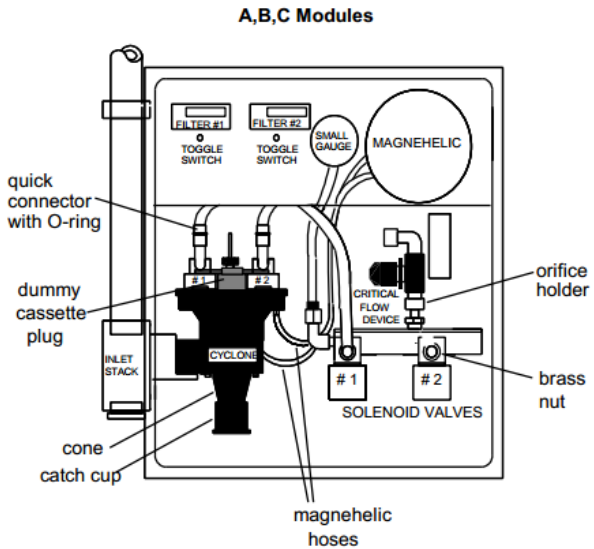
Eighty years have passed since the Dust Bowl, will US see another severe drought or dust bowl in the coming decades?

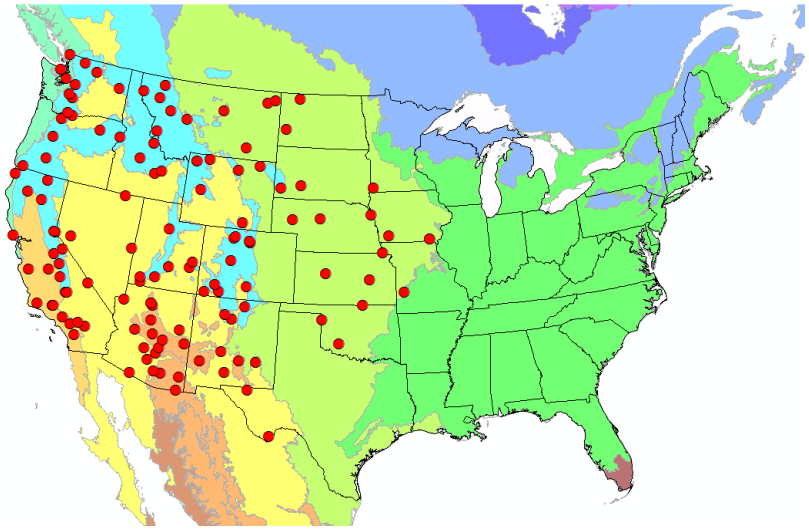
How to Develop a Dust Storm Data Set

Chinese Sand and Dust Network

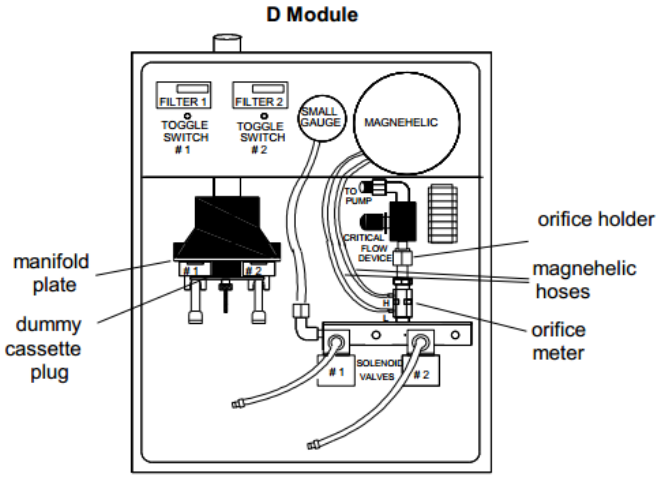


(Wang et al., 2008)





The US Aerosol Network IMPROVE



Sophisticated IMPROVE Samplers (UC-Davis)

How to identify dust storms?

- Five potential dust indicators:
  - PM10, PM2.5 (particulate matter with diameters < 10 and 2.5 micrometer) → Distinguish Dust
  - Crustal elements: Al, Si, Ca, Fe, K
  - PM2.5/PM10 Ratio

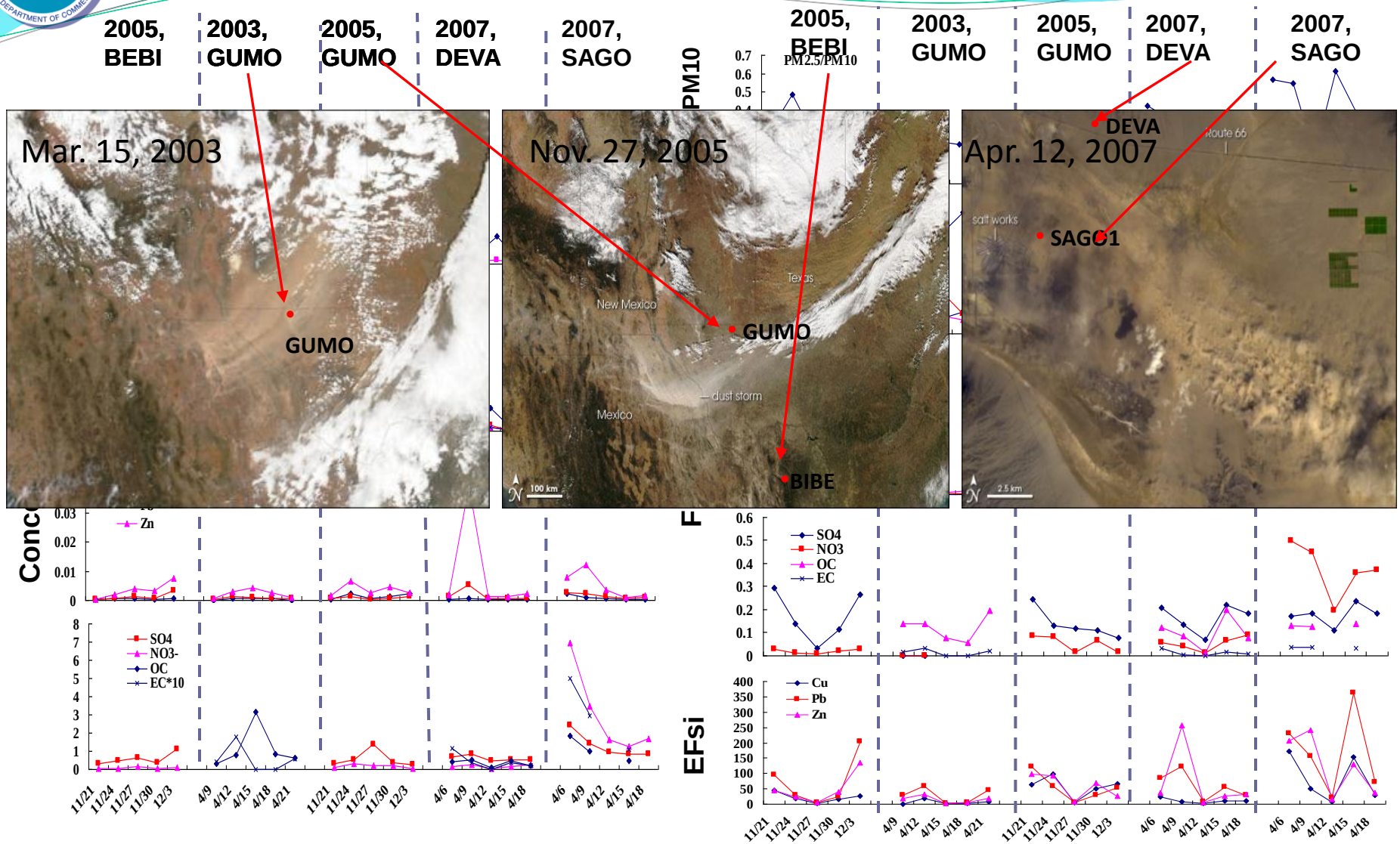
    <0.35 Local dust

    vs.

    >=0.35 Fire or transported Dust
  - Anthropogenic pollutants: As, Zn, Pb, Cu, OC, EC, Sulfate, Nitrate → High PM from Pollution vs. Dust
  - Enrichment Factor (EF): As, Zn,Pb, Cu

    where, EF =[X/Si] aerosol/[X/Si] crustal (1)

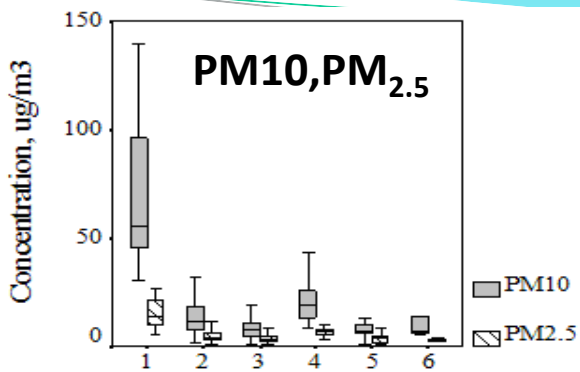
Satellite-aided Algorithm Development

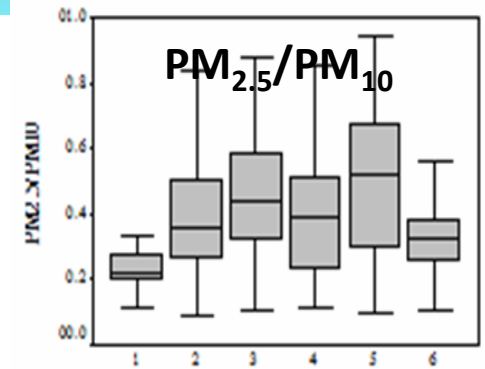


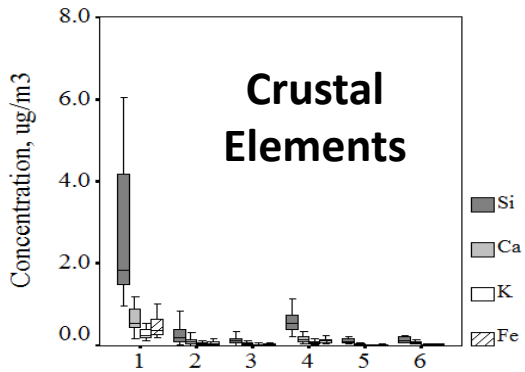
Dust Identification through Cluster Analysis

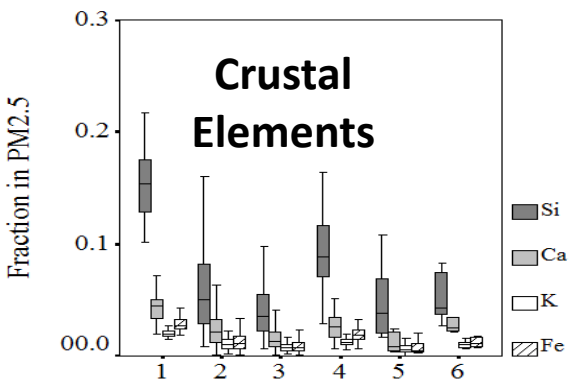
How to find dust samples:

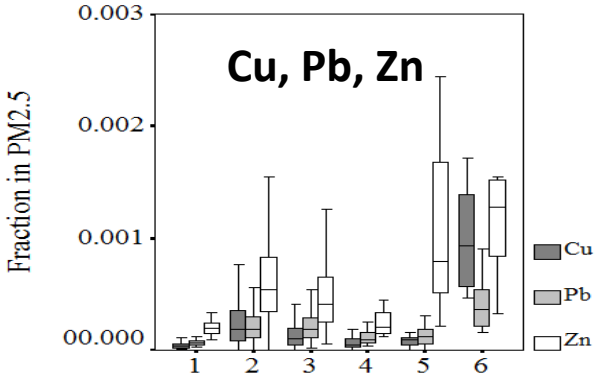
- High PM10, PM2.5 concentration
- Low PM2.5/PM10 ratio
- High concentration and percentile of crustal elements (Si, Ca,Fe, K)
- Low percentile of anthropogenic pollutants (As, Cu, Zn, Pb, SO_4^{2-},NO_3^-, EC)
- Low EF of pollution elements (Zn, Pb,Cu)

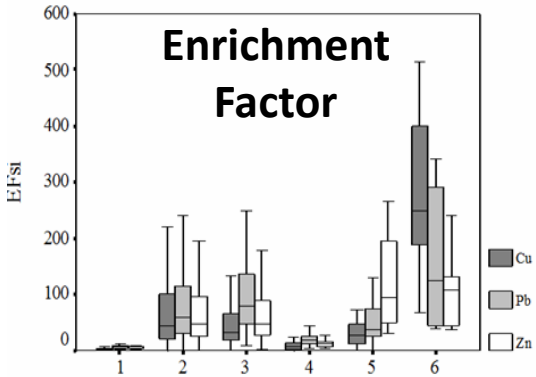






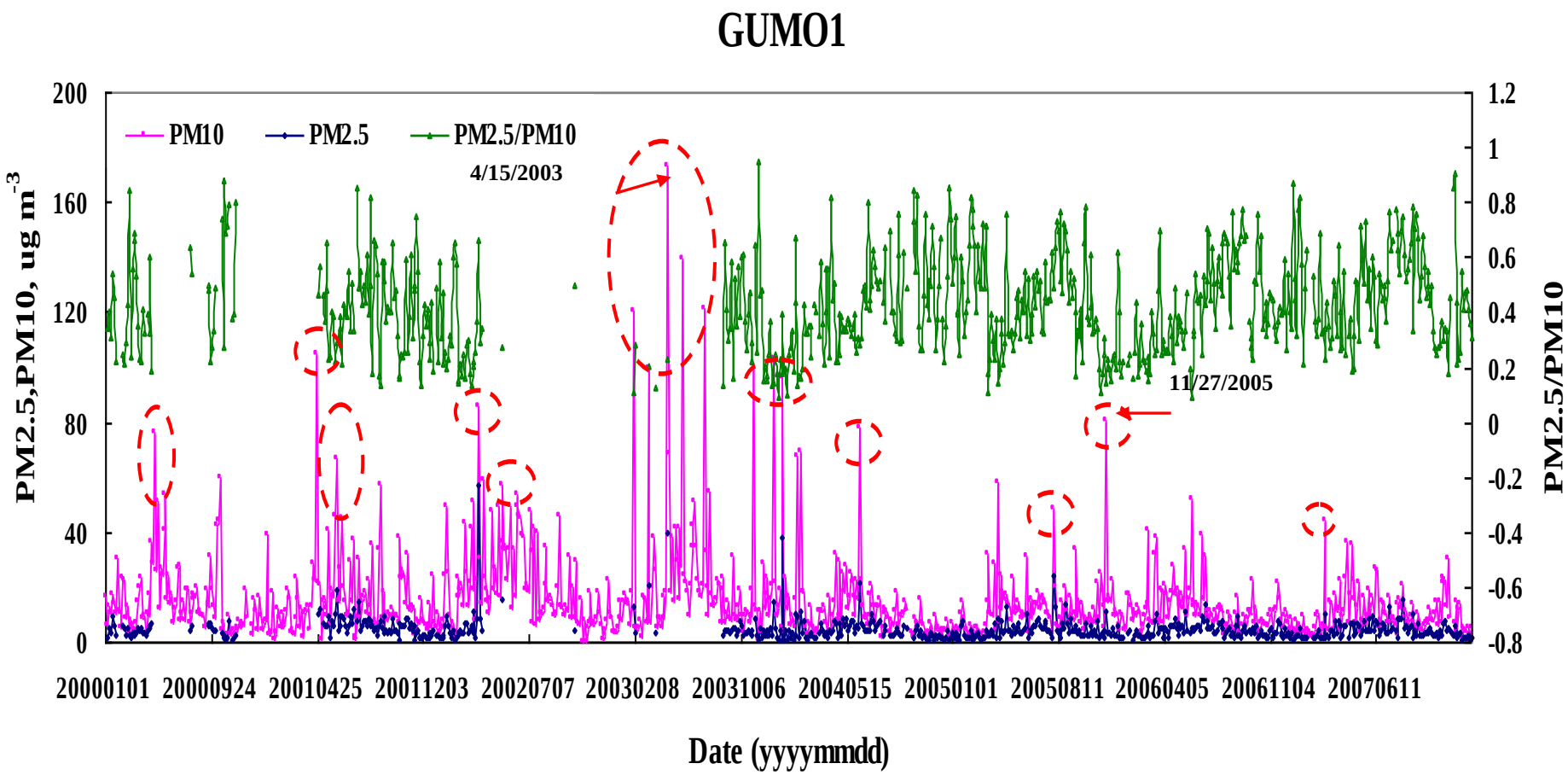






Five criteria for dust group identification

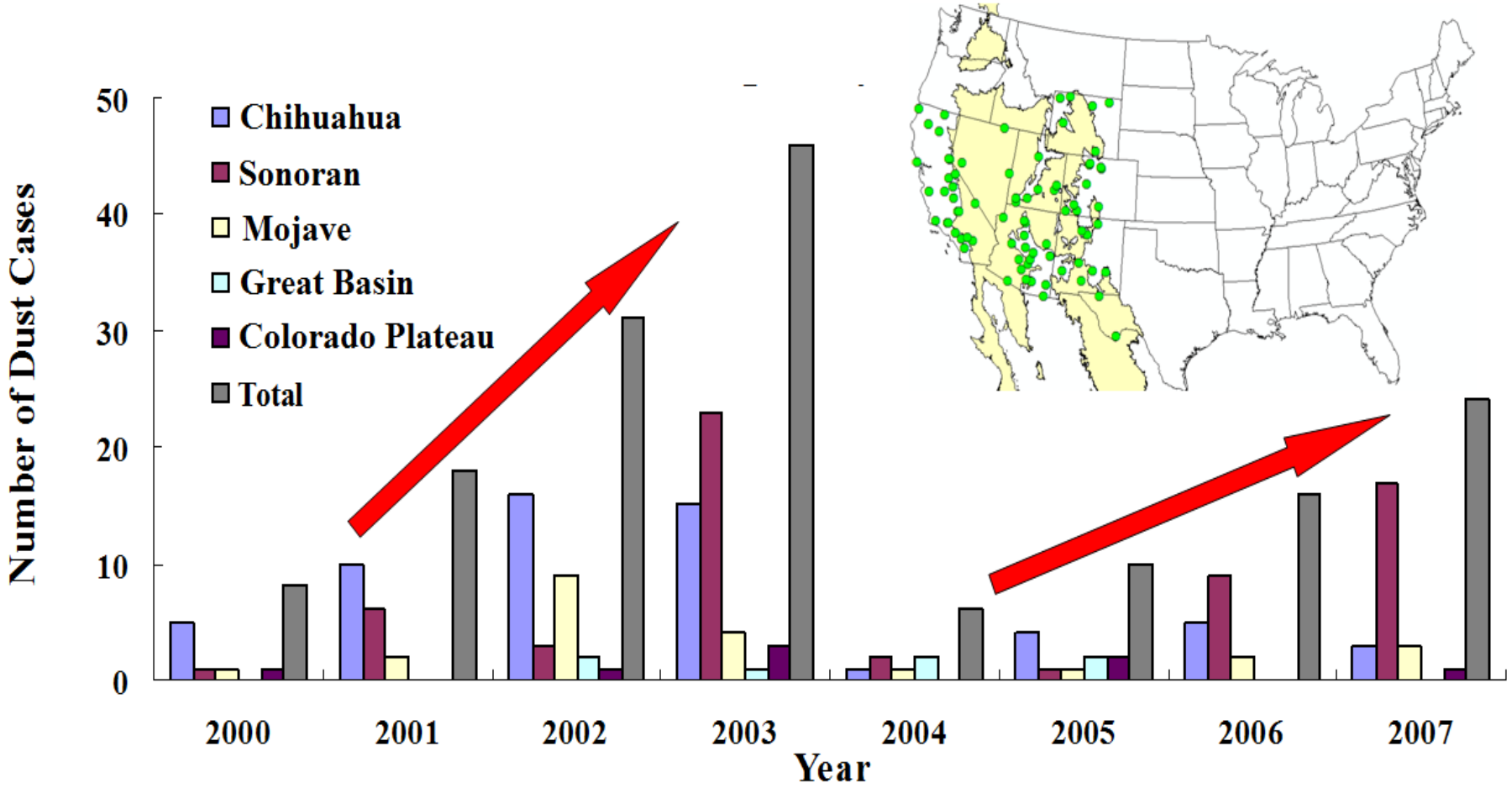
Test of the Power:
Dust Storms identified by Cluster Analysis



This algorithm, combined with Cluster analysis, can capture most of dust events.

Great!

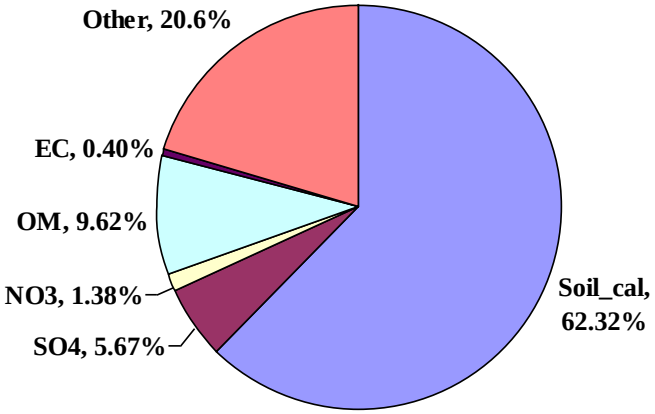
Eight-year dust climatology



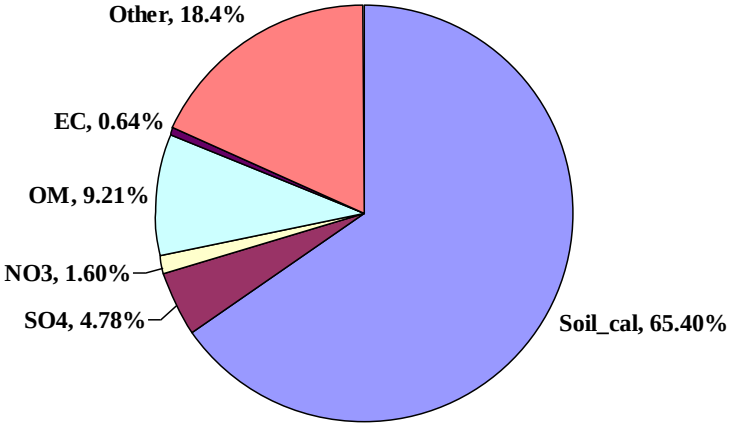
(source: Tong et al., 2012)

Chemical Composition of Dust Aerosols

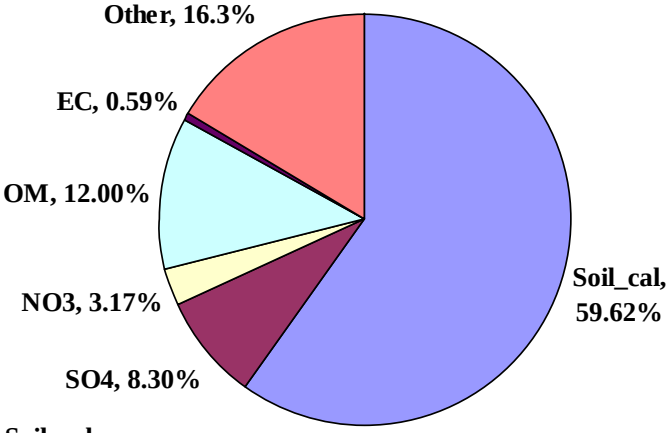
Great Basin



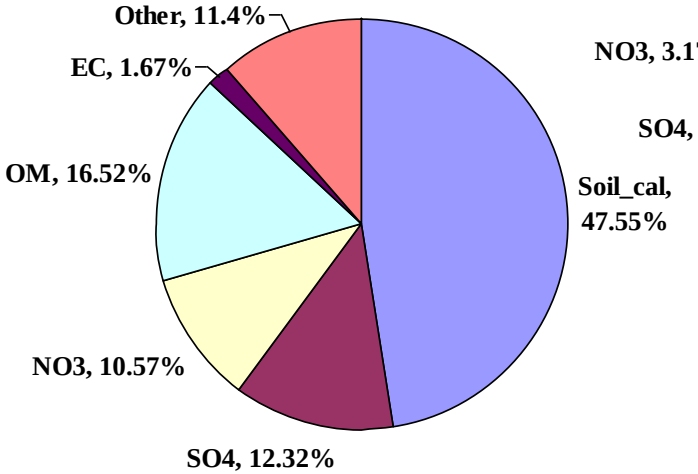
Colorado Plateau



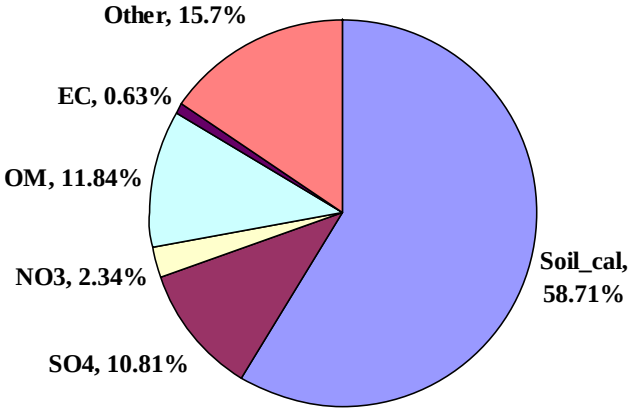
Sonoran



Mojave

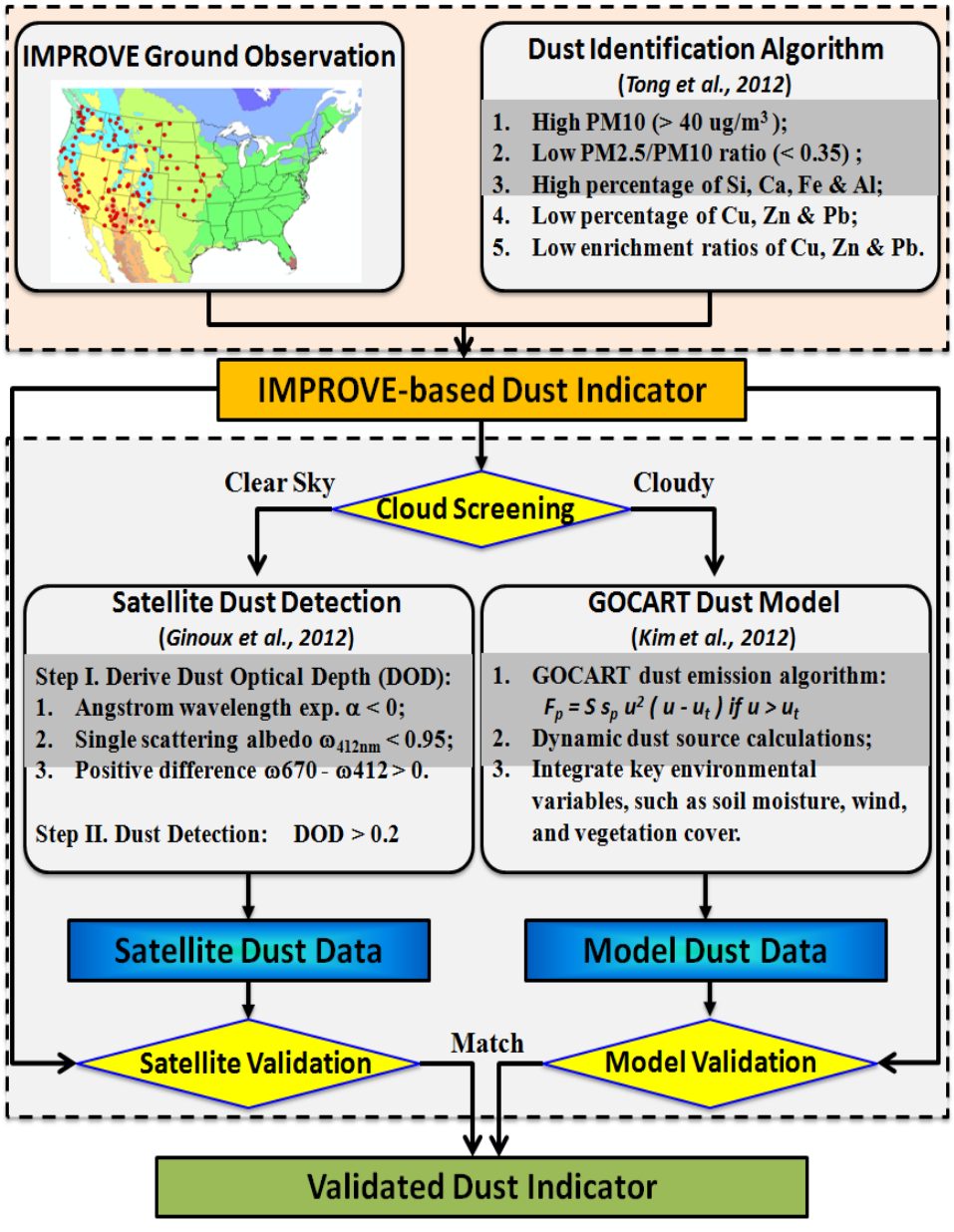


Chihuahua

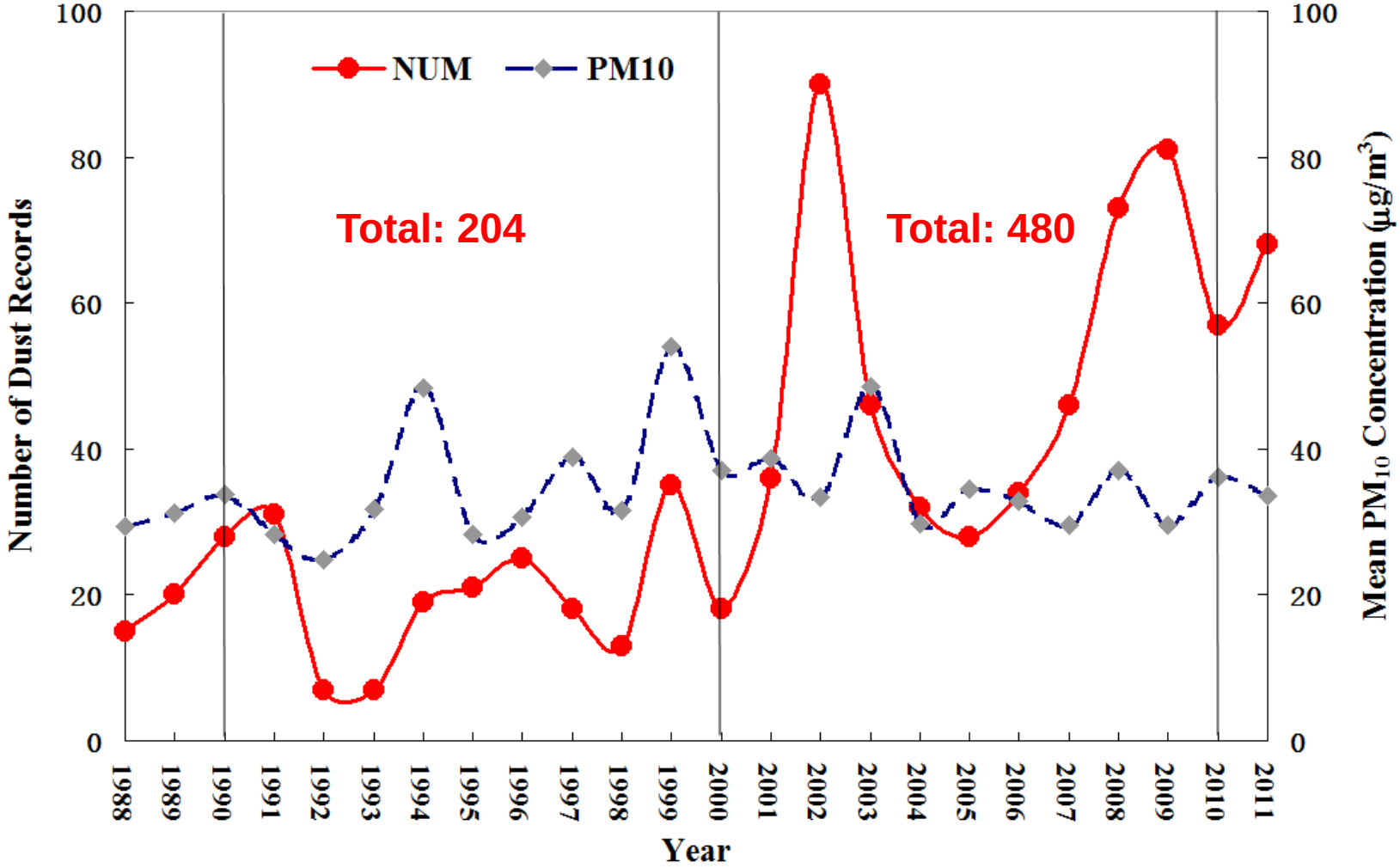


Soil_cal = 2.2*Al + 2.49*Si + 1.63*Ca + 2.42*Fe + 1.94*Ti; **OM=1.4*OC;**

Ongoing: Validation of the Dust Records



Long-term dust climatology

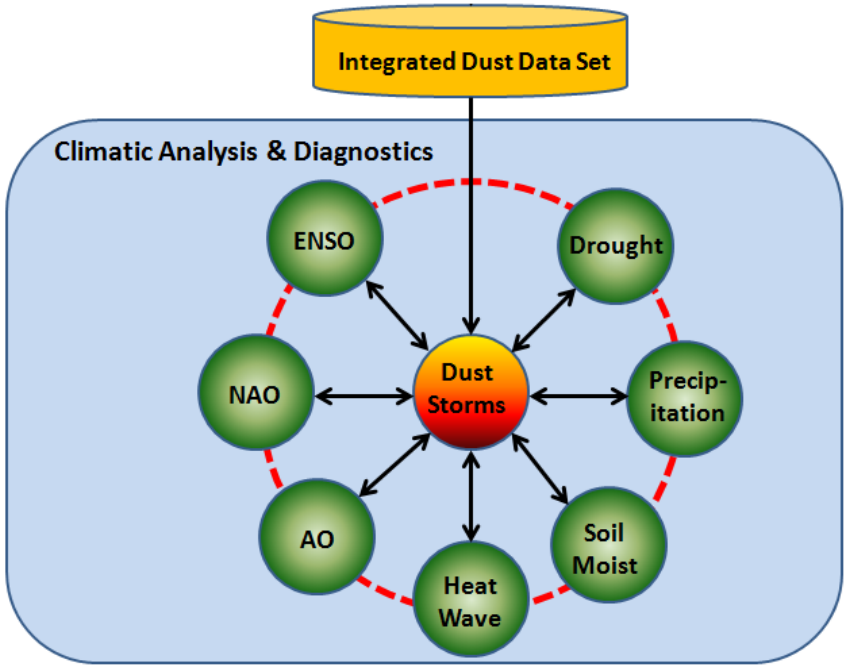


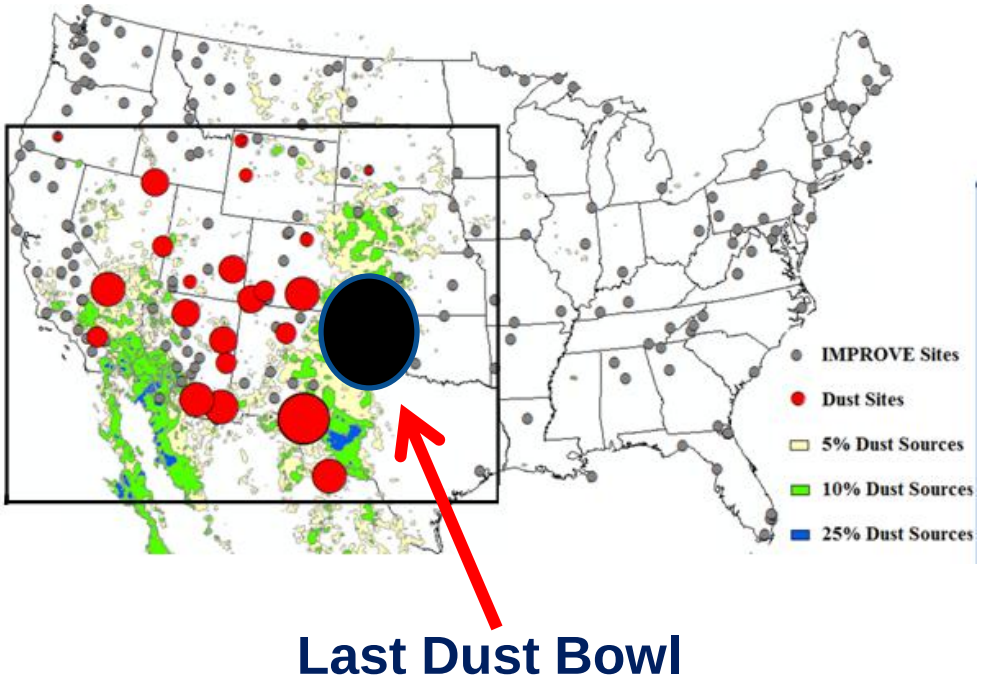
<u>Number of dust storms doubled in the past two decades</u>;
Magnitude of dust storms stay unchanged;

Open Questions:

✓ **What is controlling the dust trend?**

✓ **Is the increasing trend an early indicator to another Dust Bowl?**





Take Home Message

- ✓ **Dust storms are an important climatic force;**
- ✓ **Dust trend can be used as a climate indicator;**
- ✓ **Development of long-term dust dataset helps monitor this trend, but interpreting the observed data requires broad knowledge of the driving forces.**

Acknowledgement

✓ NASA ROSES National Climate Indicator grant to support satellite and model validation;

✓ EPA, NASA, US NPS and others for collecting the IMPROVE, MODIS and other datasets;