



# **A New Dust Dataset from the IMPROVE Ground Network**

**Daniel Tong, Julian Wang, Hang Lei and Barry Baker**  
NOAA Air Resources Laboratory, College Park, MD

**Thomas Gill**  
University of Texas at El Paso, TX

**Binyu Wang**  
George Mason University, Fairfax, VA

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# The “Dust Bowl” During the Great Depression (1930s)



- ◆ **Dust Bowl:** A period of severe dust storms during the 1930s;
- ◆ **Causes:** Extended droughts and poor land management;
  - ✓ **Homestead Acts:** settlement over the Plains for agriculture ;
  - ✓ **“Rain follows the plow”:** unusually wet climate;
  - ✓ **New agricultural machinery:** Deep plowing, eliminating native grass;
  - ✓ **Favorable dust storm conditions during 1930s drought;**





# The "Dust Bowl"



## Impacts:

- ✓ Stripped 75% of top soils over thousands of farms;
- ✓ Destroyed agriculture and ecosystem (~1950s);
- ✓ > 500,000 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***



Hundreds of thousands fled the 1930s US Dust Bowl; more drought-spurred migrations are expected.



# Another “Dust Bowl”?



- ◆ Central U.S. plains saw severe droughts about once or twice a century over the past 400 years (Woodhouse & Overpeck, 1998).
- ◆ This recurring trend may be enhanced global climate change (Schubert et al., 2004).
- ◆ Global warming → Precipitation shift from subtropics, greater evaporation, less snow/ice, and earlier spring → amplify the effects of natural climatic variations → intensified droughts and “dust-bowlification” (Romm, 2011).

(Source: Romm, 2011)



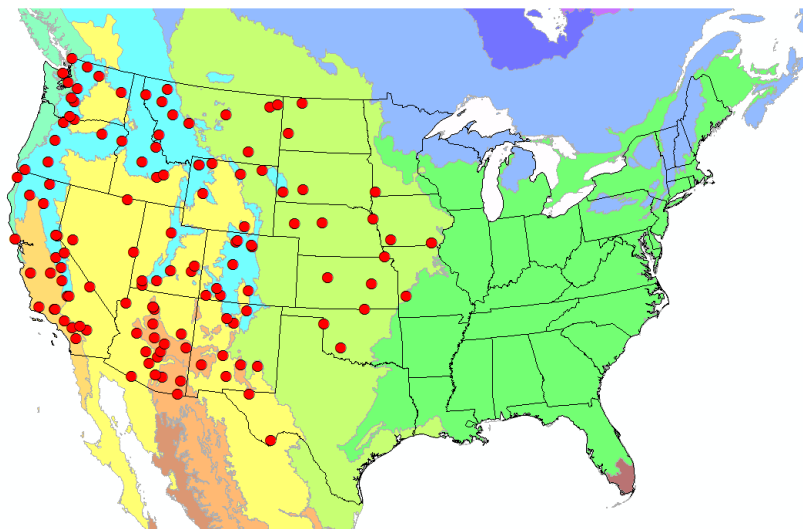
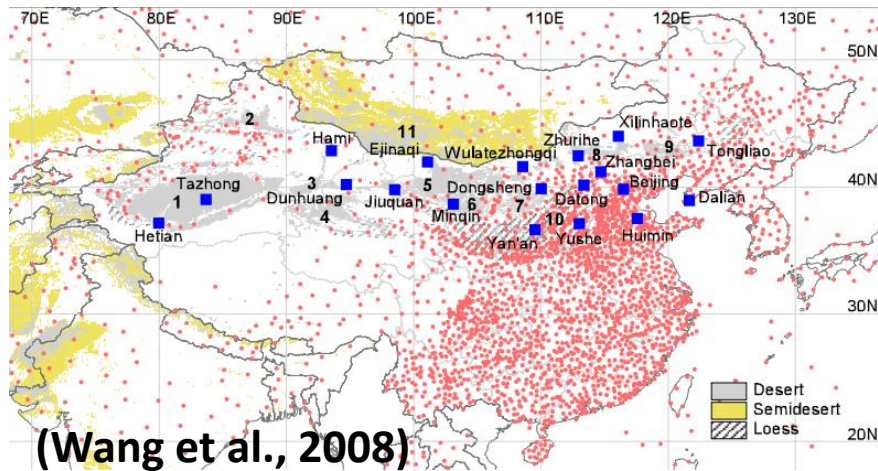
Then and now: sun-baked dry soils kick up clouds of dust in the 1930s (left) and in the modern United States (right).



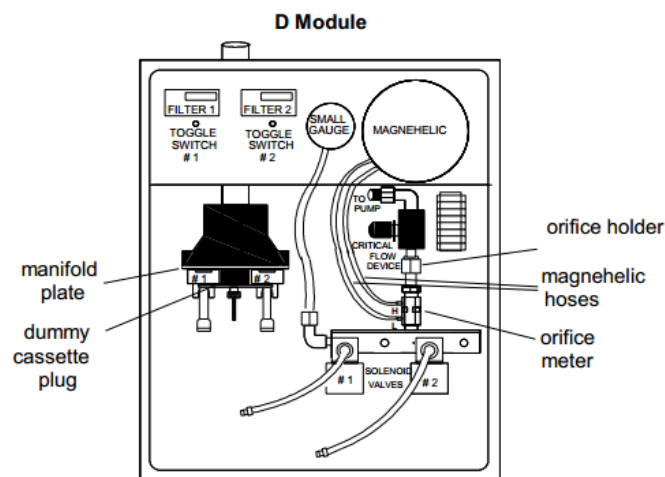
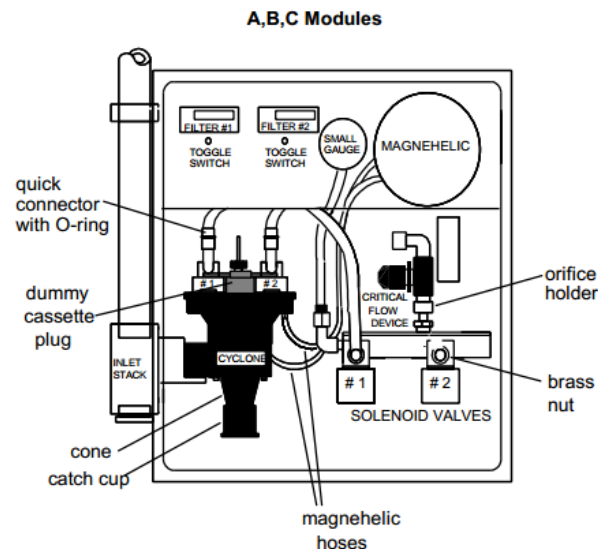
# How to Monitor Dust Storms



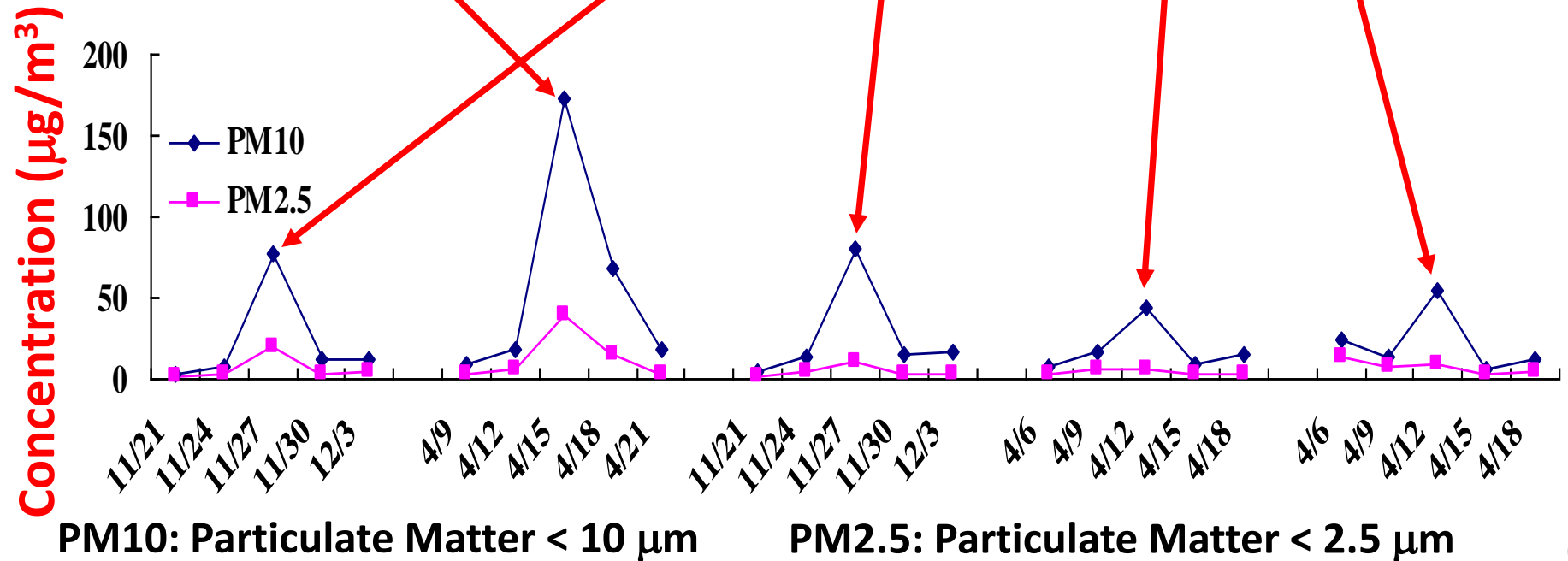
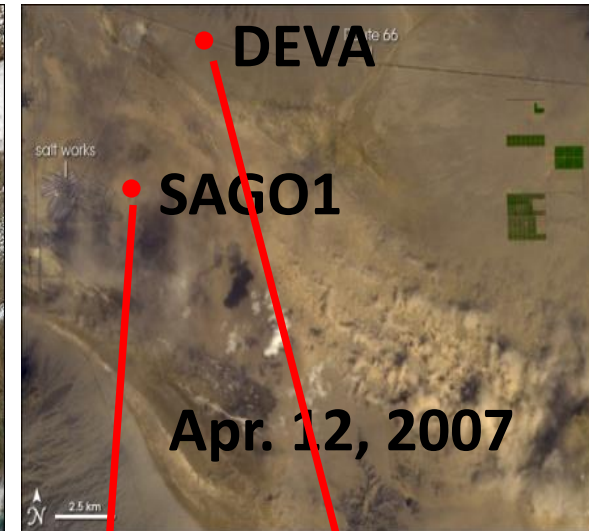
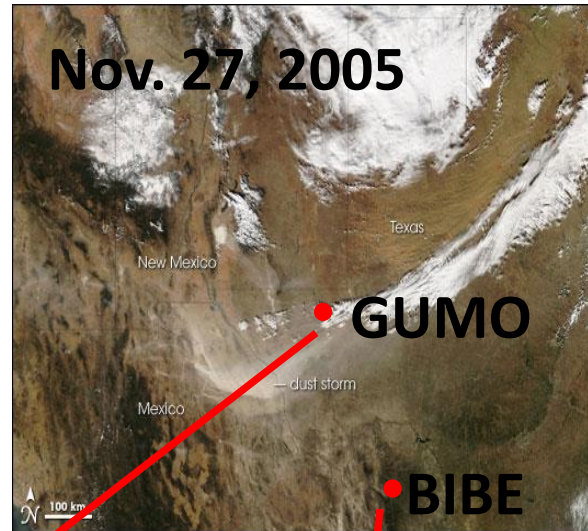
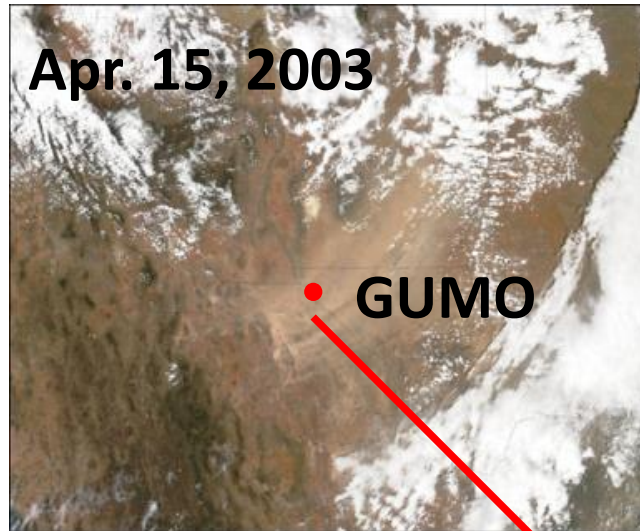
## Chinese Sand and Dust Network

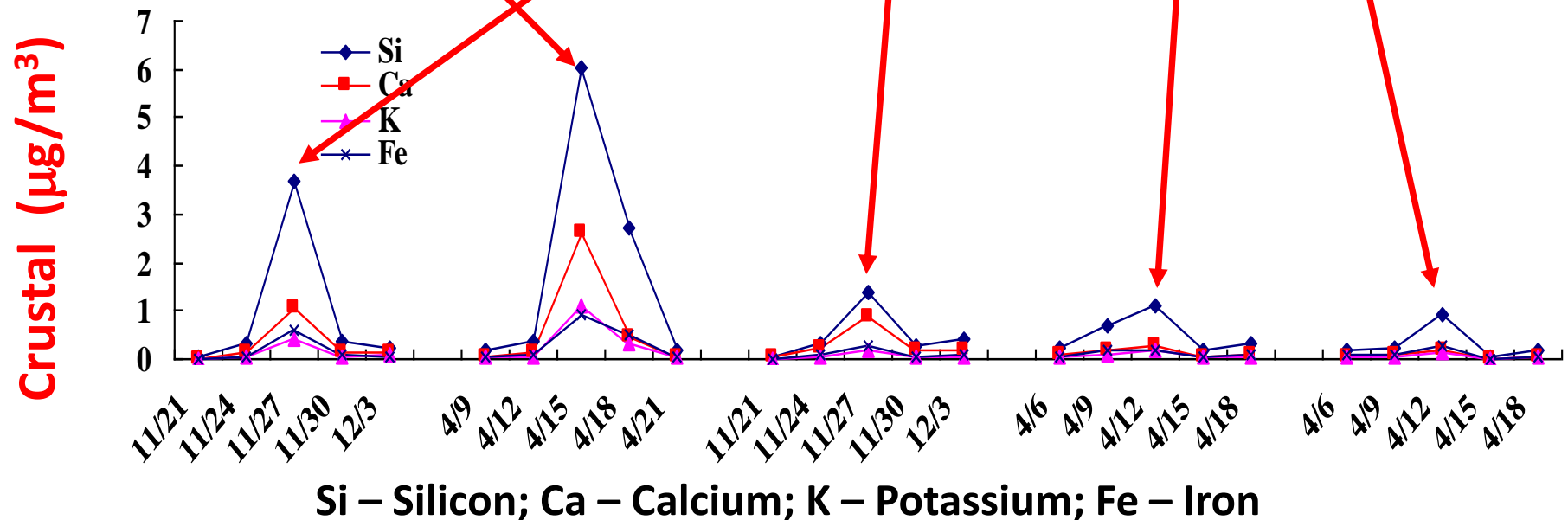
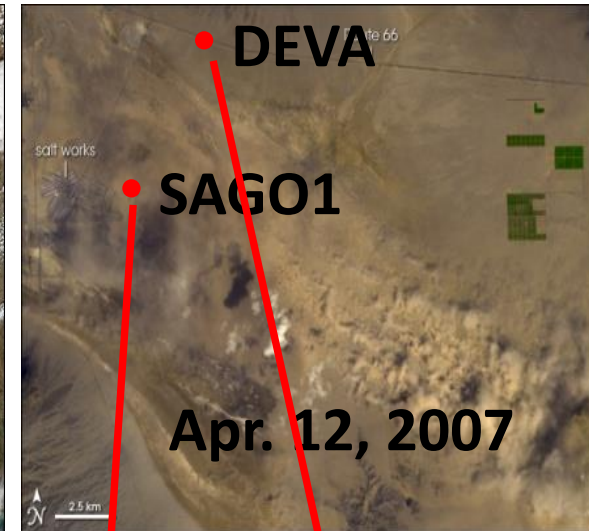
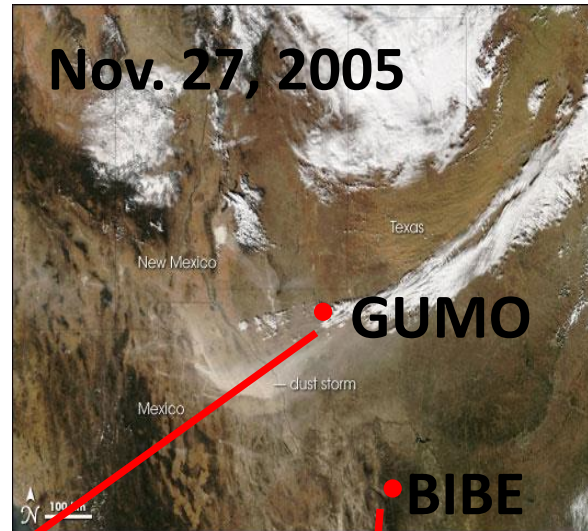
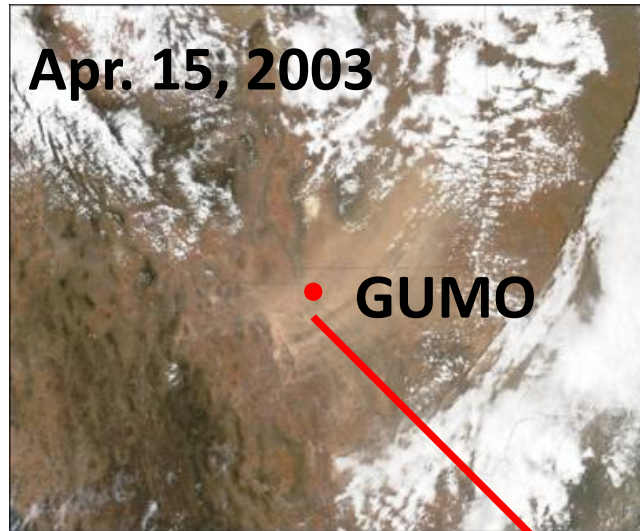


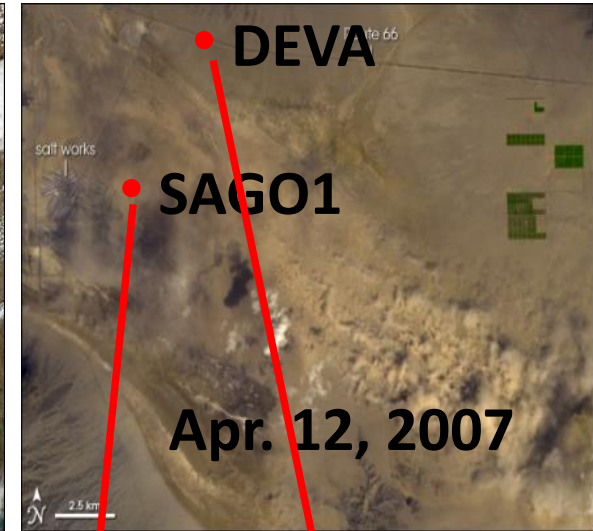
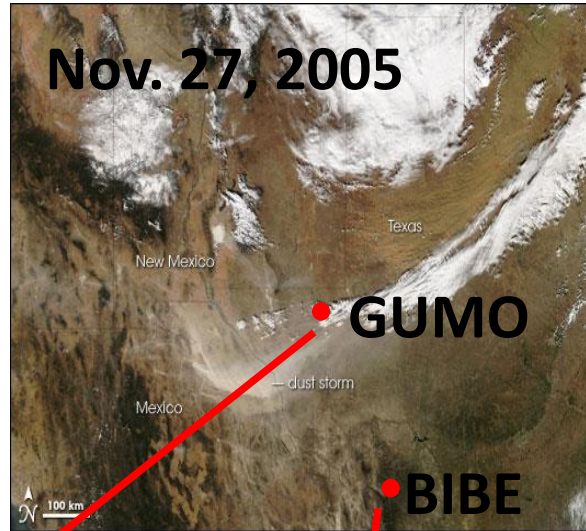
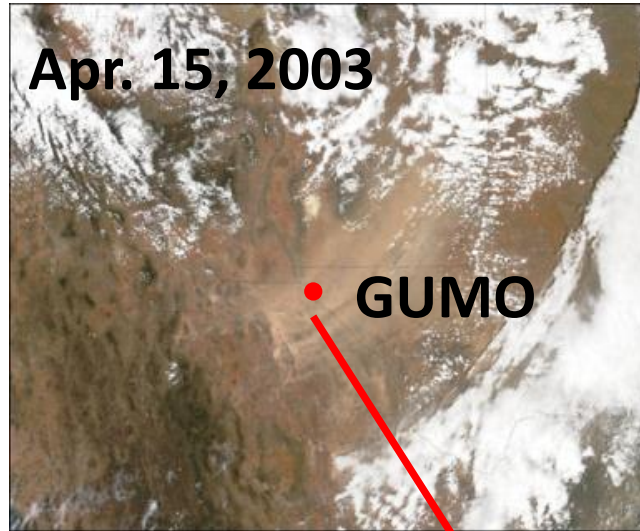
The US Aerosol Network IMPROVE



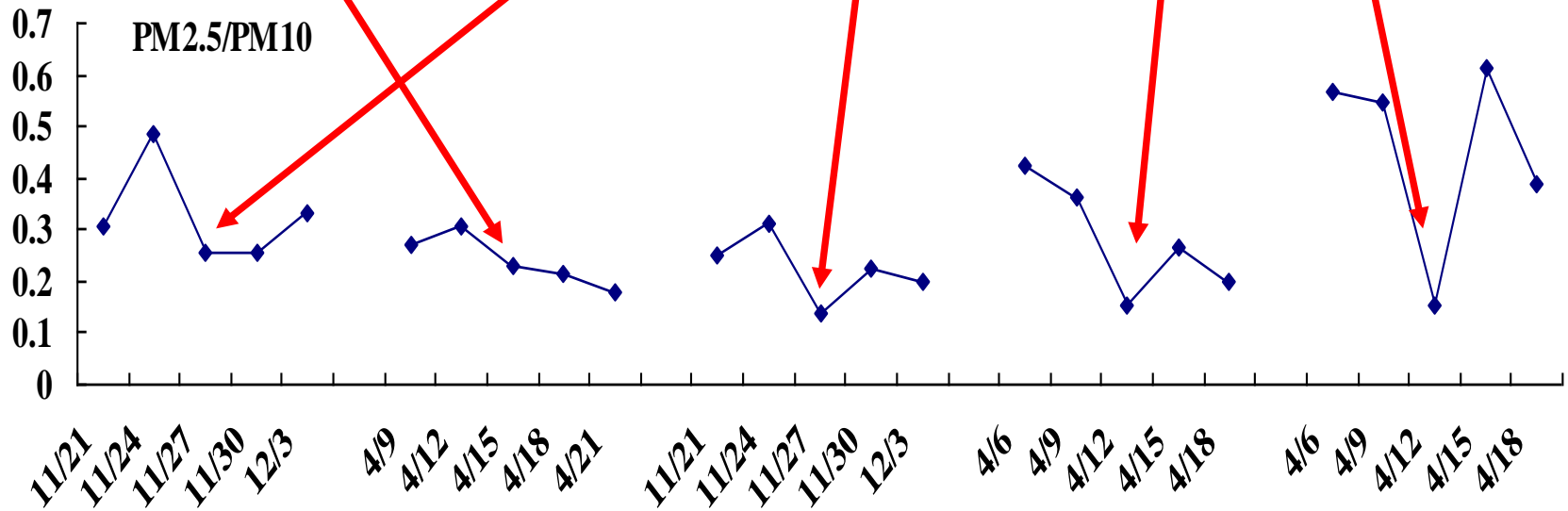
IMPROVE Samplers  
Samples Analyzed at UC-Davis







PM25/PM10 Ratio





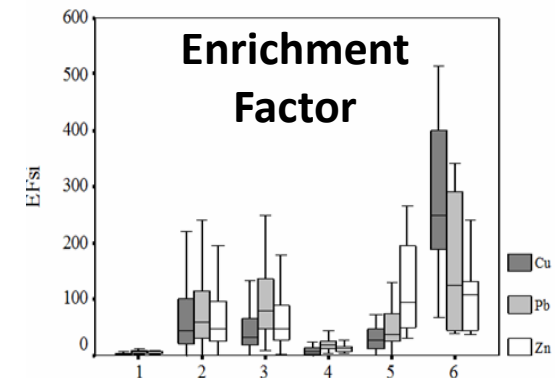
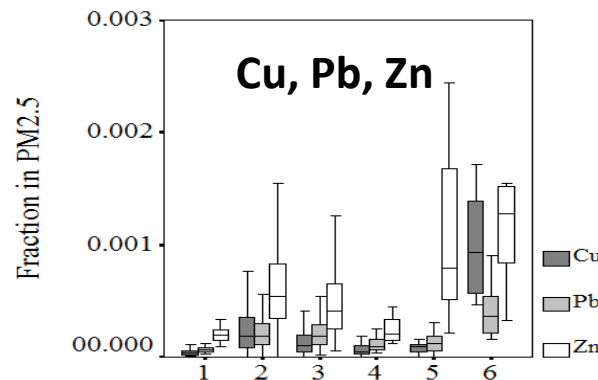
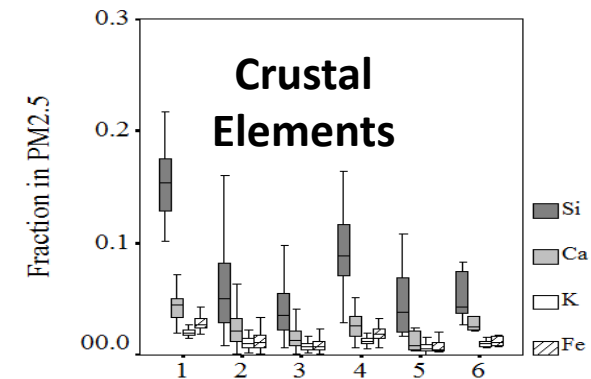
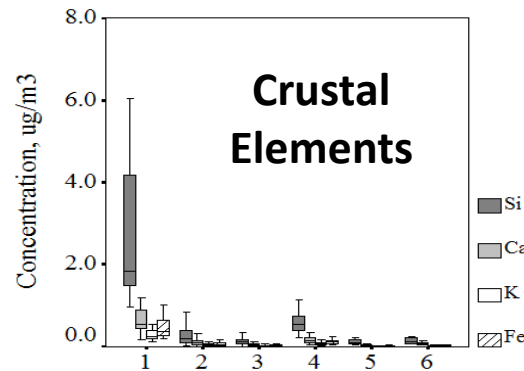
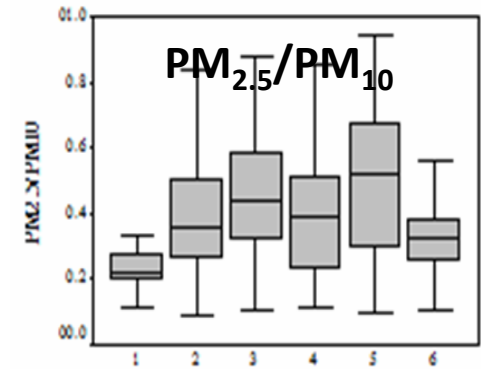
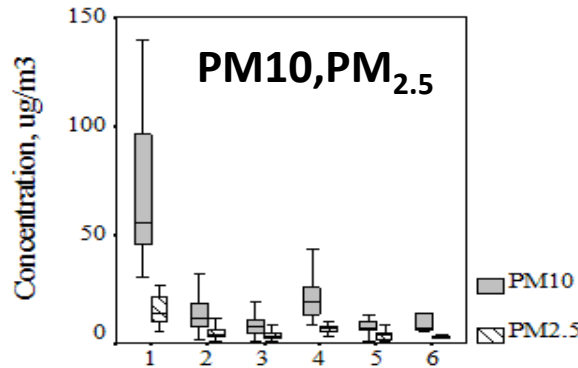
# Dust Identification through Cluster Analysis



## Five Dust Indicators:

- ❖ High  $PM_{10}$ ,  $PM_{2.5}$ ;
- ❖ Low  $PM_{2.5}/PM_{10}$  ratio
- ❖ High Crustal Fraction
- ❖ Low anthropogenic Fraction;
- ❖ Low Enrichment Factor;

Cu – Copper  
Pb – Lead  
Zn – Zinc

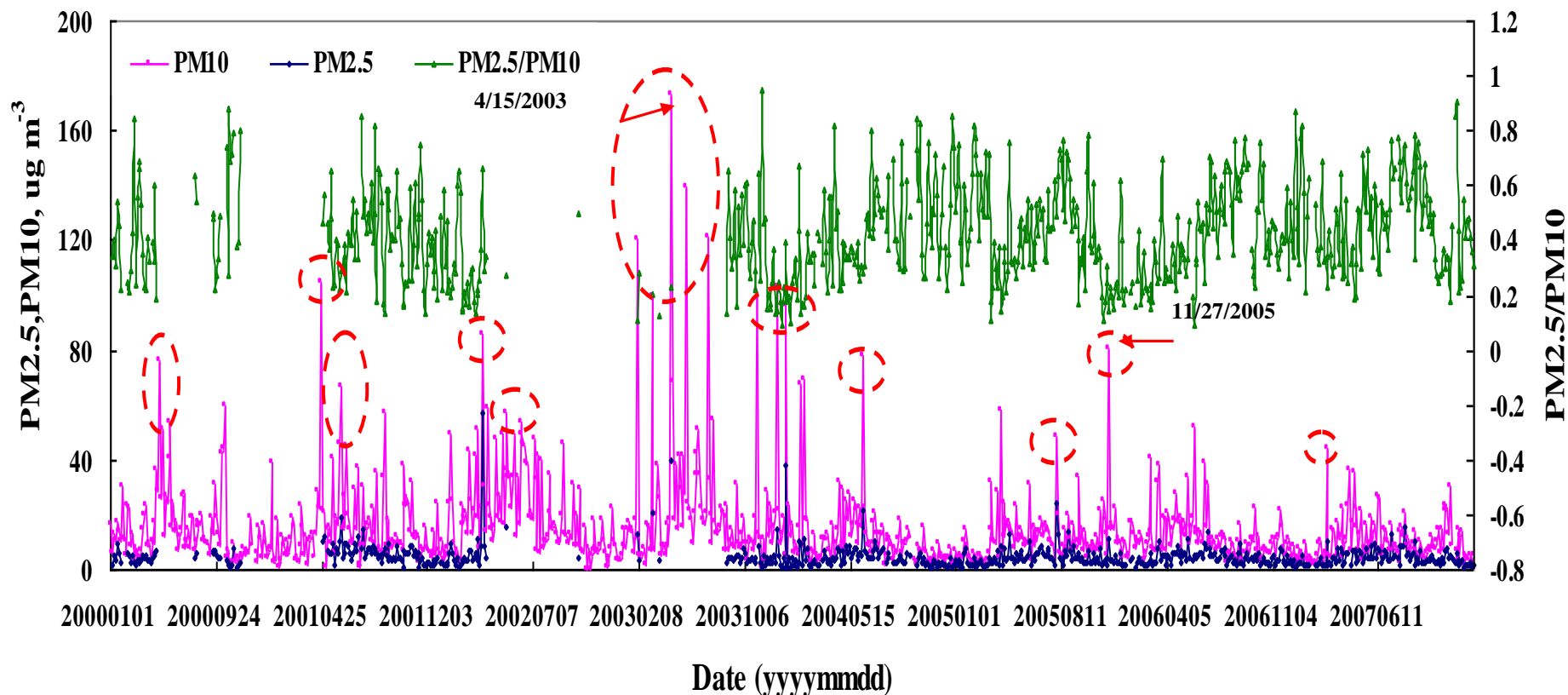




# Detecting Dust Storms



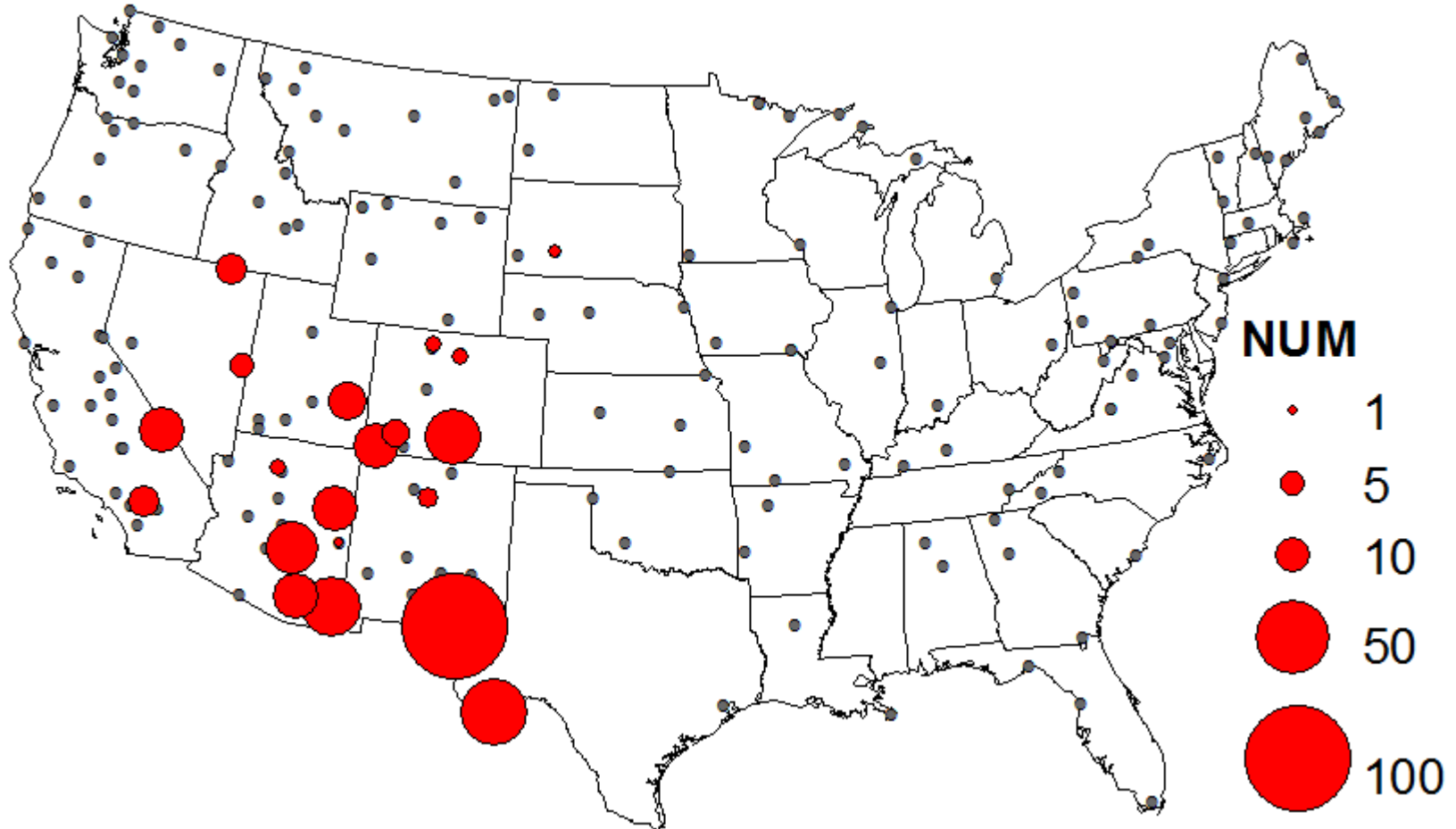
## Guadalupe Mountains National Park



(Source: Mo Dan)

**This algorithm, combined with cluster analysis, can pin-point dust.**

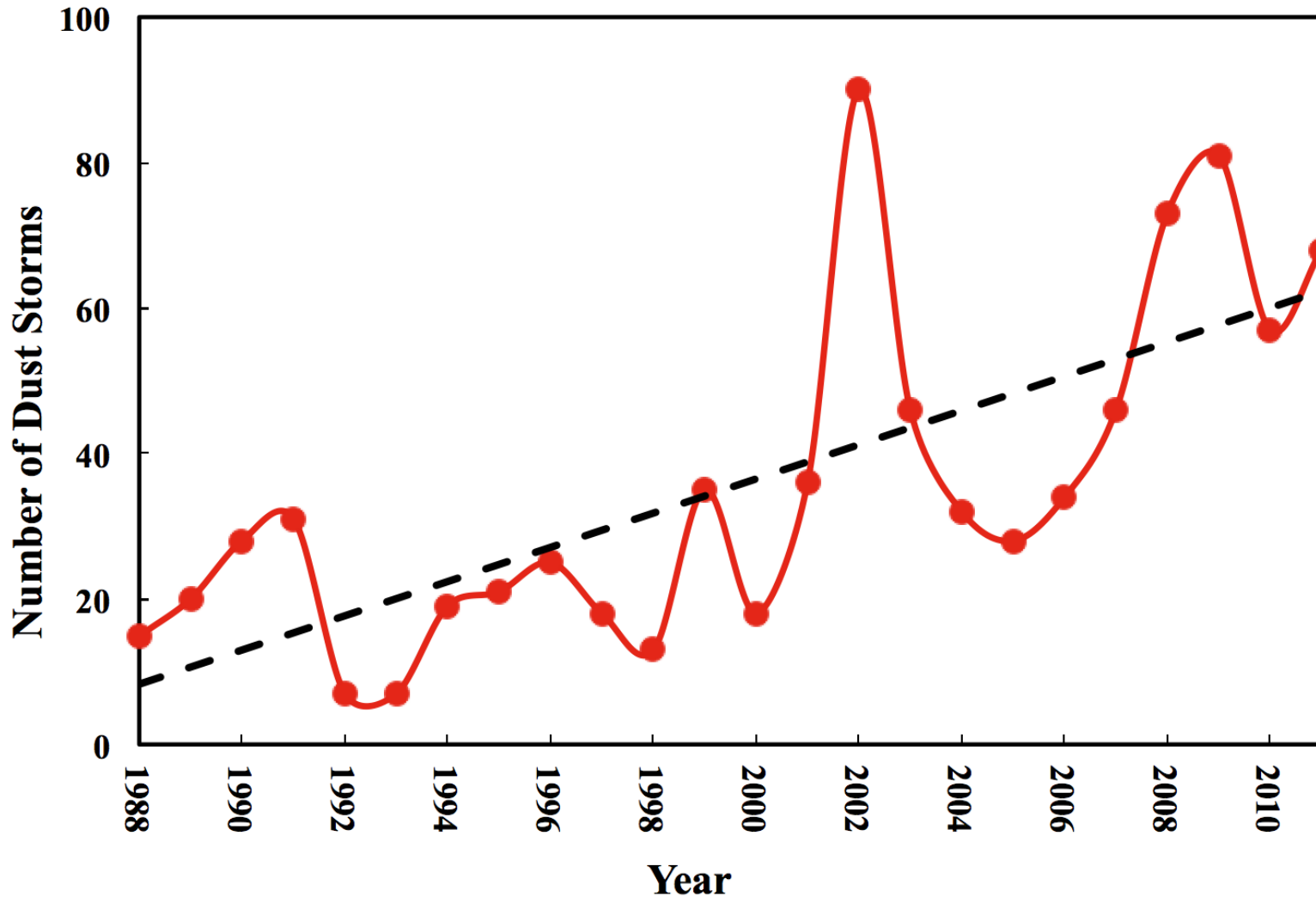
# Locations of Dust Storms



Dust storms detected at 29 sites with continuous data records.



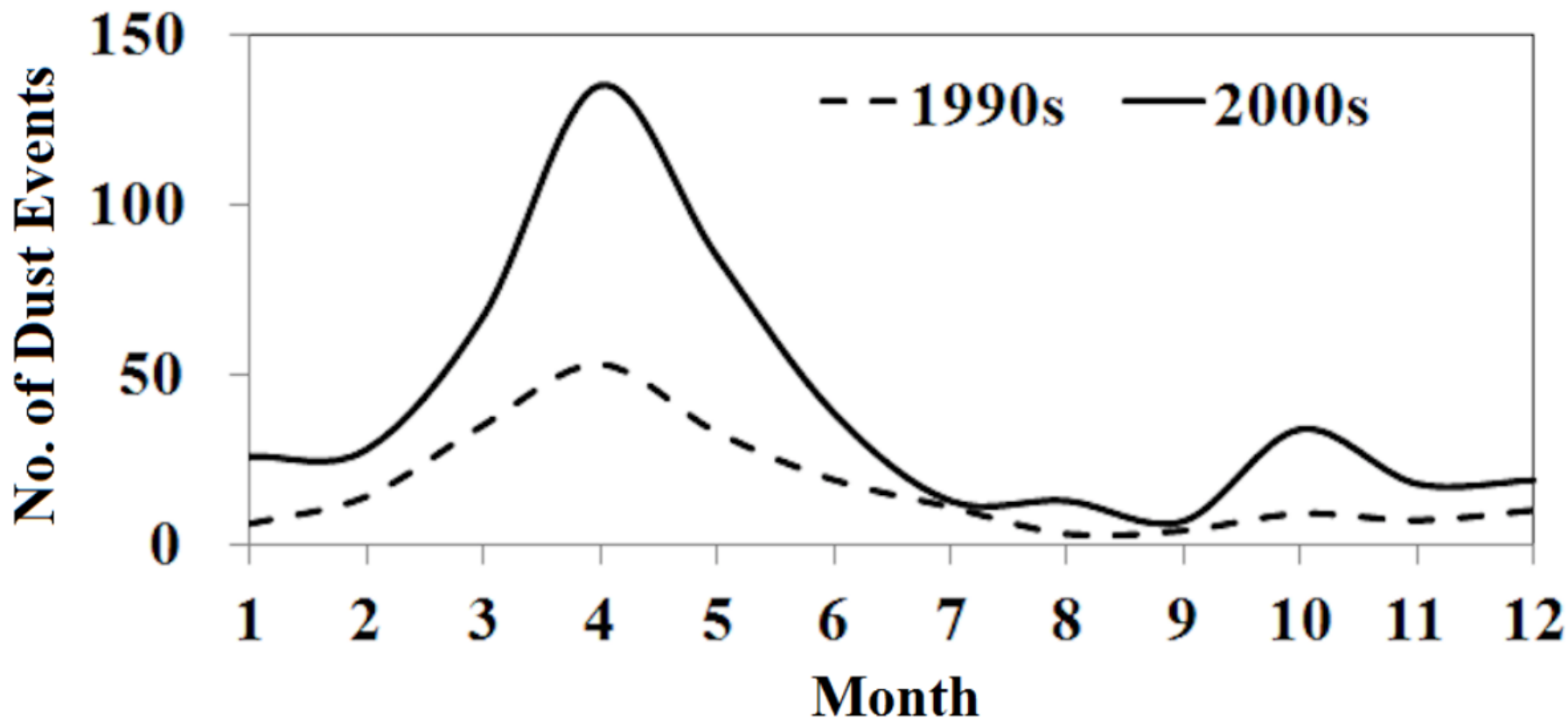
# Long-term Dust Trend



**20 Giant Storms in 1990s → 48 Storms in 2000s;**



# Seasonal Variation



**Increase in Spring (mostly) and Fall;**

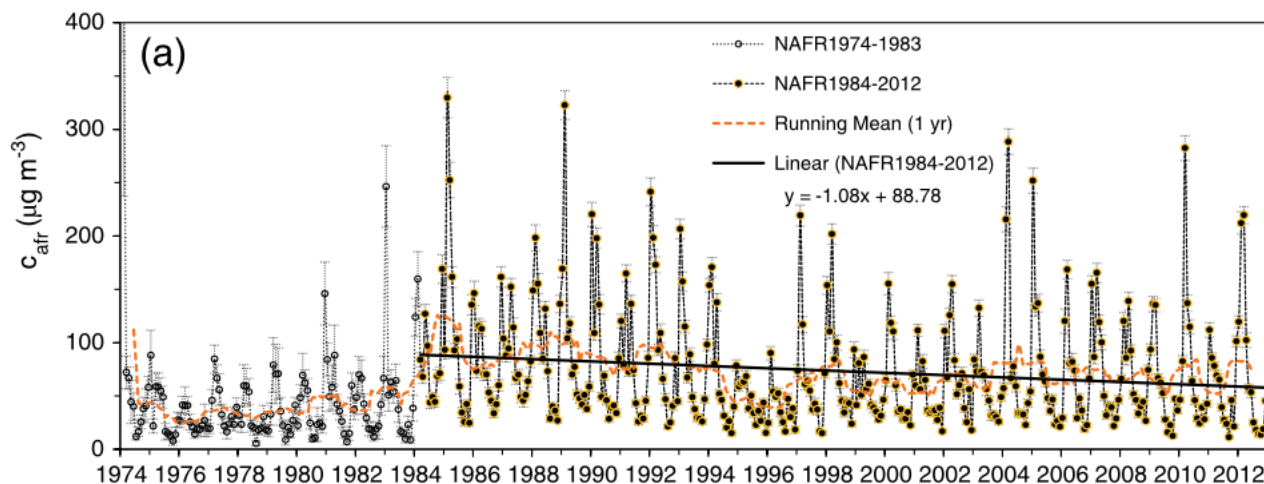
**Almost no change in Summer/Wet Season;**



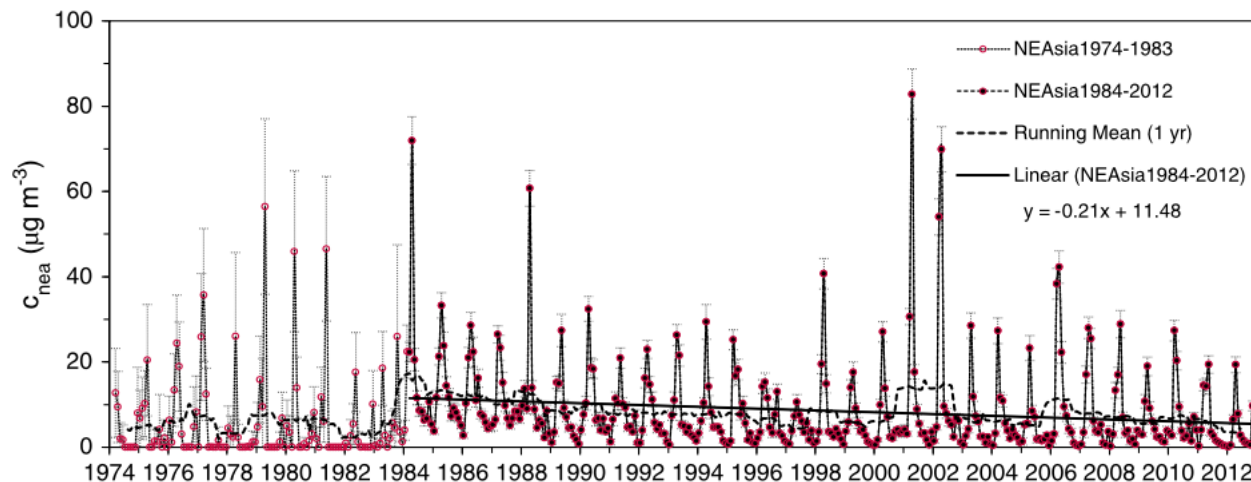
# Decreasing Dust Trends in Asia and Africa



(Shao et al., 2013)



**Northern  
Africa**

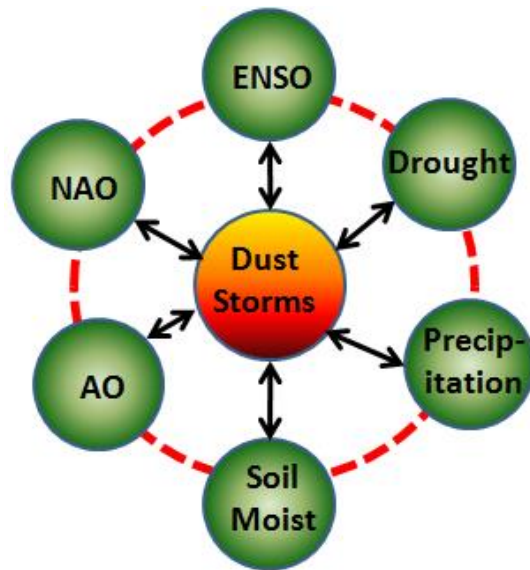


**Northern  
Asia**

**Global dust concentration decreased  
at 1.2%/yr from 1984 –2012**

# What Drives the Dust Trend?

(Contributed by Hang Lei)



**ENSO** - El-Nino Southern Oscillation

**PDO** - Pacific Decadal Oscillation

**NAO** - North Atlantic Oscillation

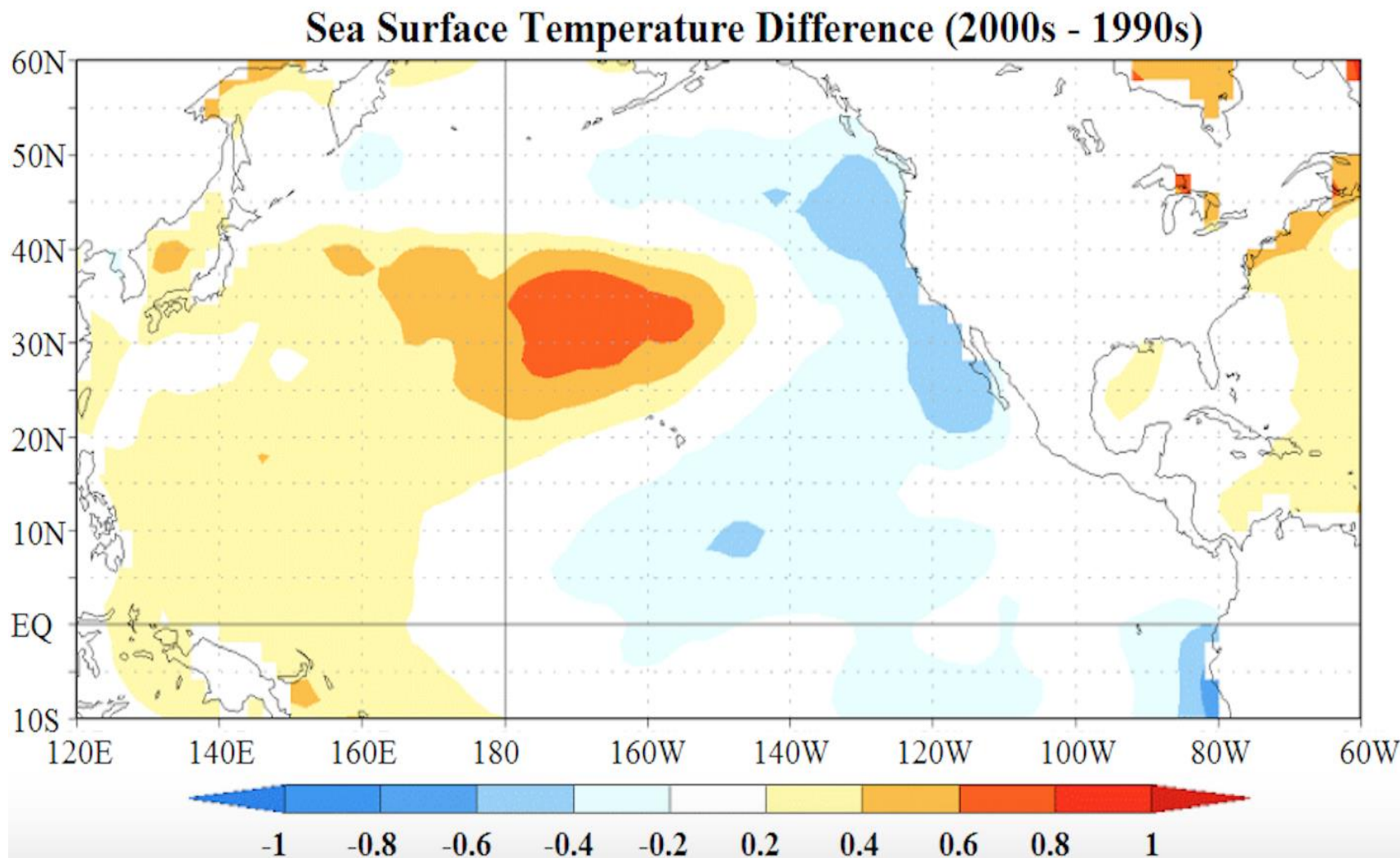
**PNA** - Pacific/North American Oscillation

**AO** - Arctic Oscillation

	ENSO	PDO	NAO	PNA	AO
<b>LL-dust</b>	-0.44	-0.62	-0.41	-0.33	0.38
<b>HL-dust</b>	-0.32	-0.73	-0.40	-0.56	0.33

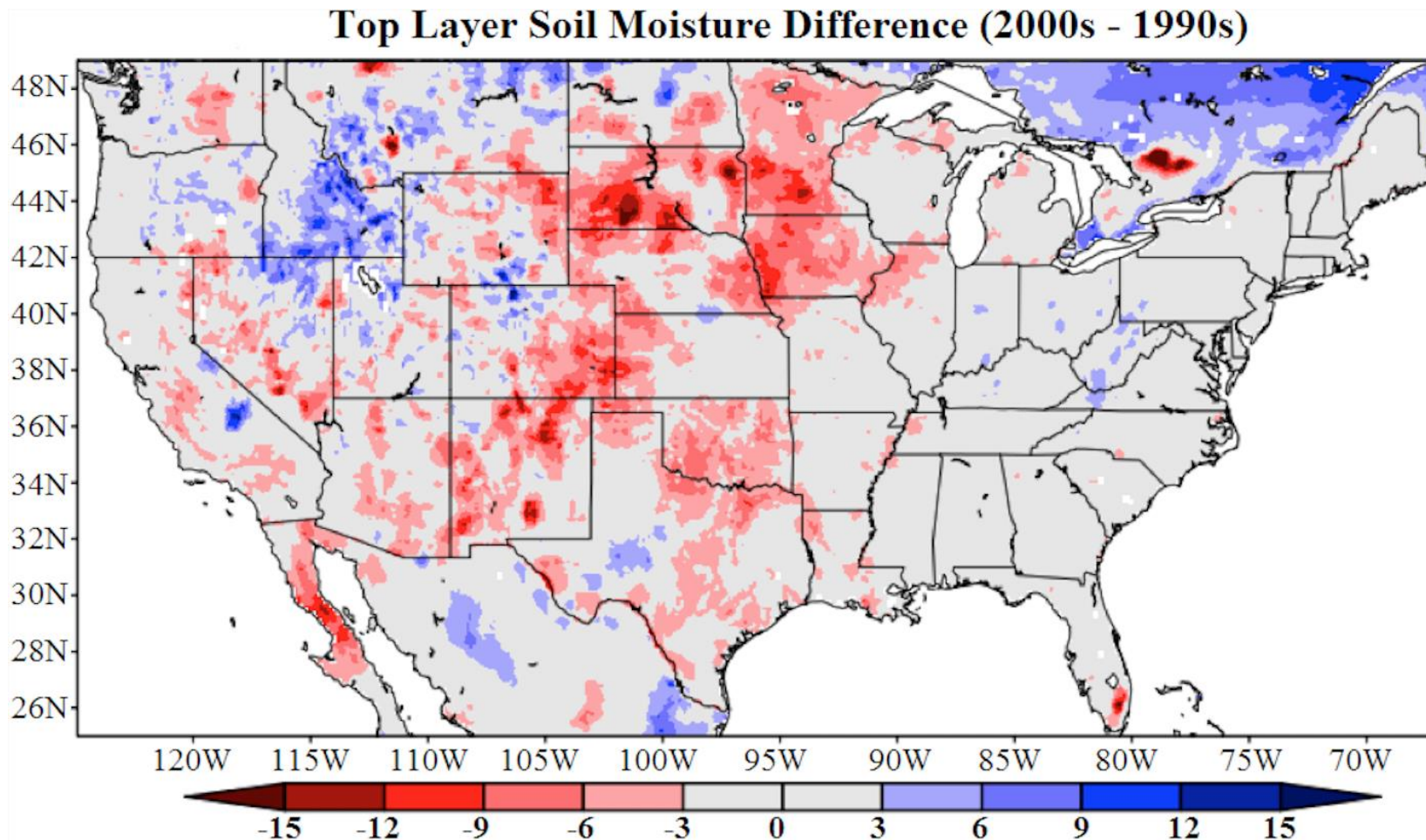
**LL** – Low Latitude North American deserts (Chihuahua, Mojave, and Sonoran);  
**HL** – High Latitude Deserts (Great Basin and Colorado Plateau)

# Changes in Sea Surface Temperature



(Contributed by Julian Wang)

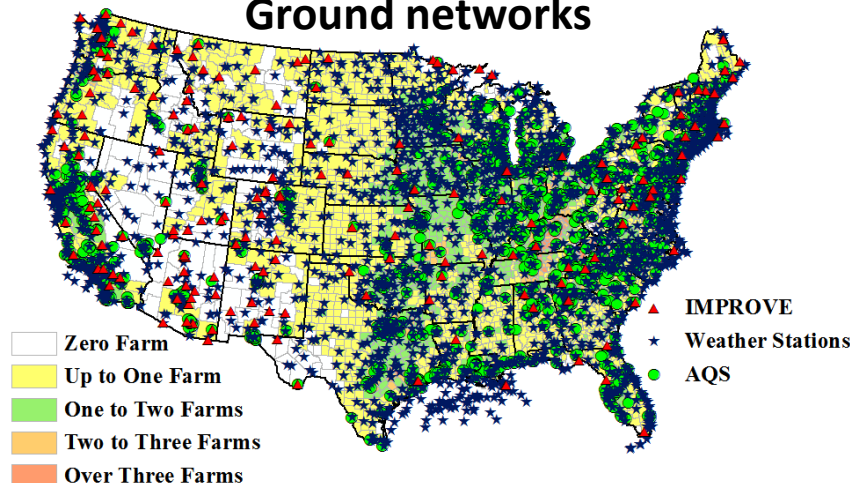
# Changes in Soil Moisture



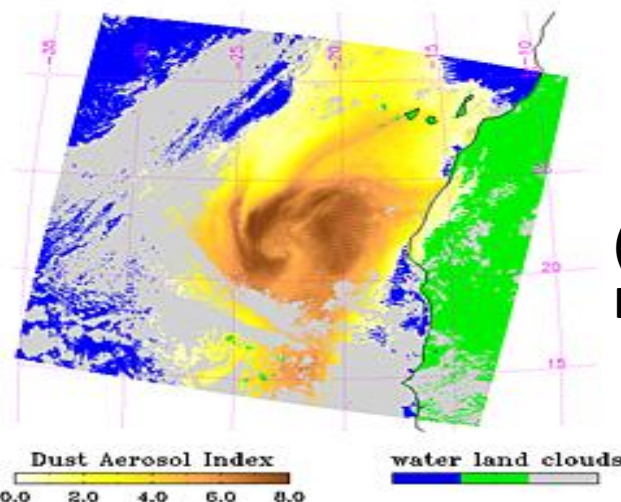
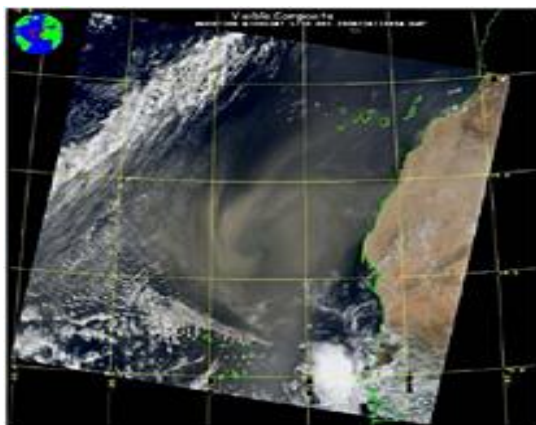
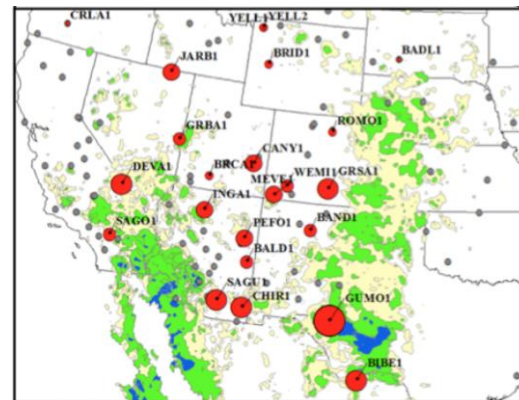
(Contributed by Julian Wang)

# What's Next?

## Ground networks



## IMPROVE vs MODIS Dust Frequency (MODIS data - Ginoux et al., 2012)



(source: Ciren and Kondragunta, 2014)

- Build community consensus on the long-term trend;
- Use ground data for satellite product validation.



# Summary



- ◆ **We developed a new dust identification method for IMPROVE dataset for VIIRS Dust validation**
- ◆ **The frequency of dust storms more than doubled from 1990s to 2000s in the Southwest United States.**
- ◆ **The dust trend is likely driven by large-scale variations of sea surface temperature in the Pacific Ocean.**

- **Further information:**

Tong et al., Atmospheric Chemistry & Physics, 2012;

Lei et al., Climate Dynamics, 2016;

Tong et al., Geophysical Research Letter, 2017;



# Acknowledgment & Data Access

- **Funding Support:** NASA ROSES and NOAA USWRP;
  - **Data:** EPA, NOAA, NASA, CDC and Arizona DHS;
  - **Many colleagues** for inspiring discussion.
- 
- **Data Access:** Email [qtong@gmu.edu](mailto:qtong@gmu.edu)
  - **Project Website:** <http://ws.laits.gmu.edu/nca>