Toward enhanced capability for detecting and predicting dust events in the Western United States: the Arizona Case Study

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1. Background, objectives and data used

Dust in the western US

- Dust affects human life, ecosystems, and the climate. North America contributes to 0.1-5% of the world's dust emissions. Important emitters include the four major deserts (Great Basin, Mojave, Sonoran, Chihuahuan) in the western US (WUS).
- Many North American dust storms last for 2-21 hours; mechanisms and compositions vary
- Long-term observations revealed intensified dust activities in the WUS with weaker extra regional impacts
- There is need to extend and better understand the temporal changes of dust activities using diverse observations
- It's important to improve daily dust forecasting skills as well as its future projection under the changing climate

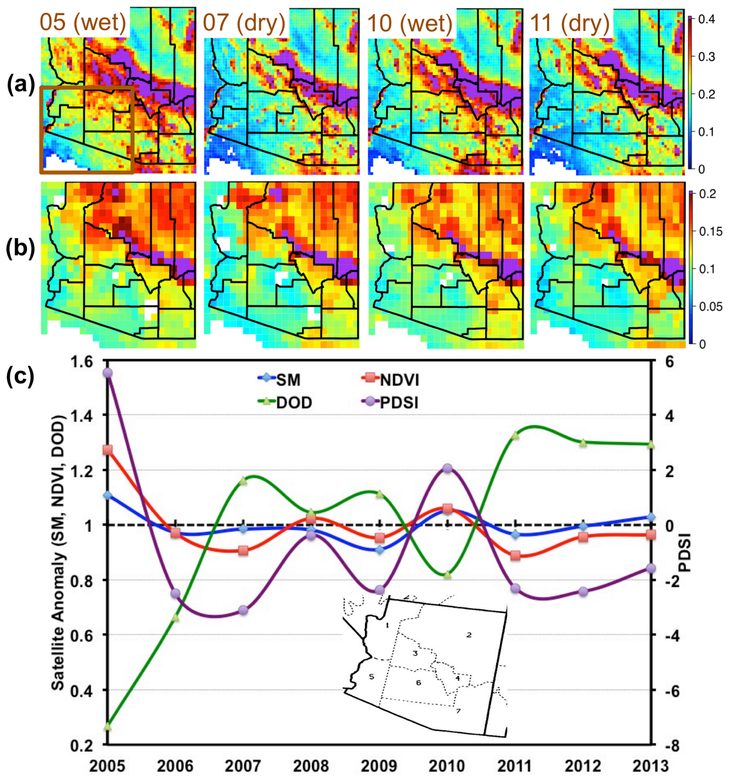
Objectives

- Develop decadal dust records in Arizona using various observations
- Understand relationships between dust activities with weather and vegetation conditions
- Evaluate the predictability of the current forecasting system during the exceptional events and suggest the directions to further improve the predictability of this system

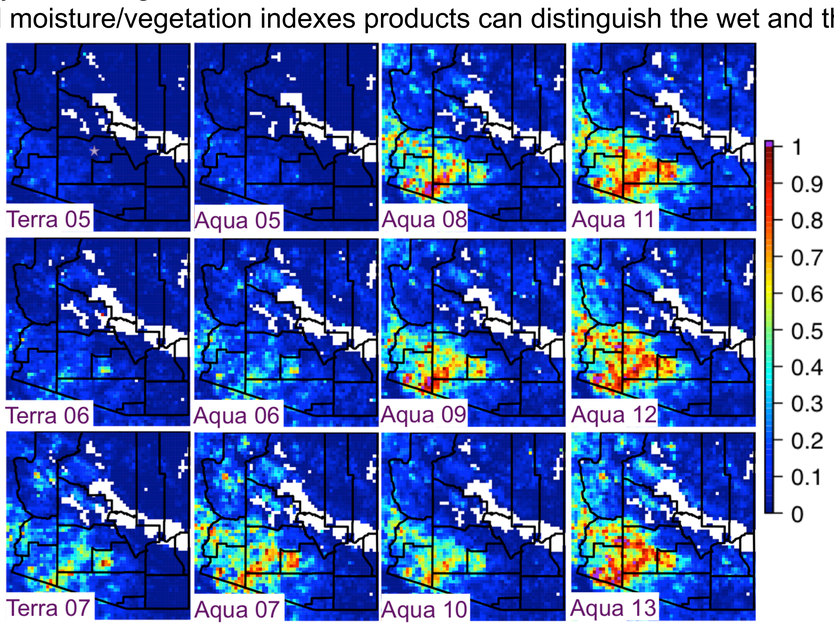
Data used

Data	Data type	Variable	Temporal resolution	Location
IMPROVE	In-situ	Particulate matter (PM)	24h average, every three days	Phoenix, AZ
AQS/AirNOW	In-situ	PM	hourly	Phoenix, AZ
AZMET	In-situ	wind	hourly	Phoenix, AZ
MODIS	Satellite (Terra/Aqua)	Deep blue AOD, NDVI	2-4 times/day, monthly	AZ
ESA multi-sensor soil moisture product	Satellite (multi-sensor)	Soil moisture	monthly	AZ
PDSI	index	Drought index	monthly	Southwestern AZ
CMAQ (12 km)	Model	PM	hourly	Western US
RAQMS (1°)	Model	Ozone, RH	6 hourly	~12 km

2. Decadal drought indicators and satellite DOD in Arizona



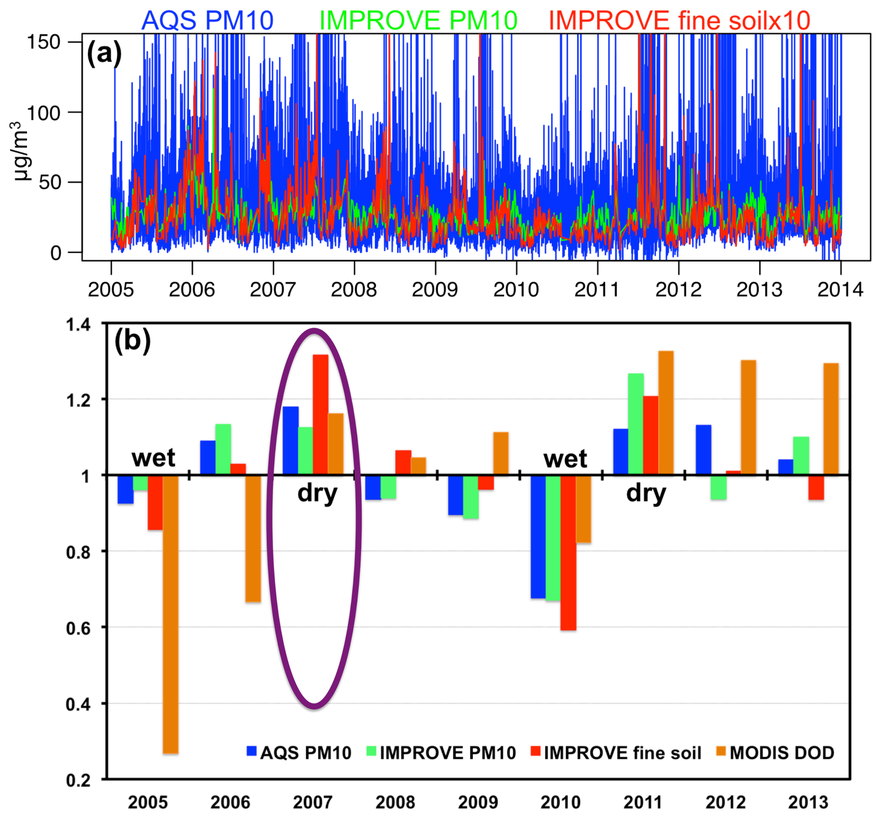
- Persistently dry (and hot) weather conditions in the past decade for spring/summer, except 05, 08, 10.
- SW AZ is dry with little greenness.
- Satellite soil moisture/vegetation indexes products can distinguish the wet and the dry years.



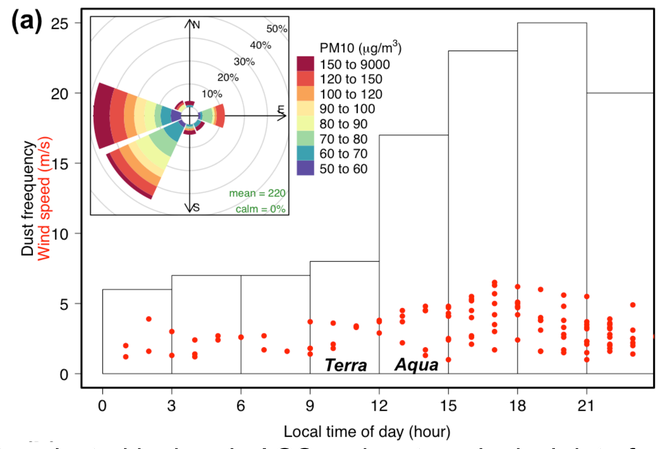
MODIS DOD: AOD screened by Angstrom and single scattering albedo (Ginoux 2012 method)

- Spatial variability: high from Sonoran desert to Phoenix
- Diurnal variability: Terra (late a.m.) < Aqua (early p.m.) in 2005-2007
- Large scale inter-annual variability: less dusty in wet years. Potential future usage of SMAP: much better coverage than the SCAN sites.

3. Surface in-situ PM measurements in Phoenix: Decadal records and case study of 2007 events

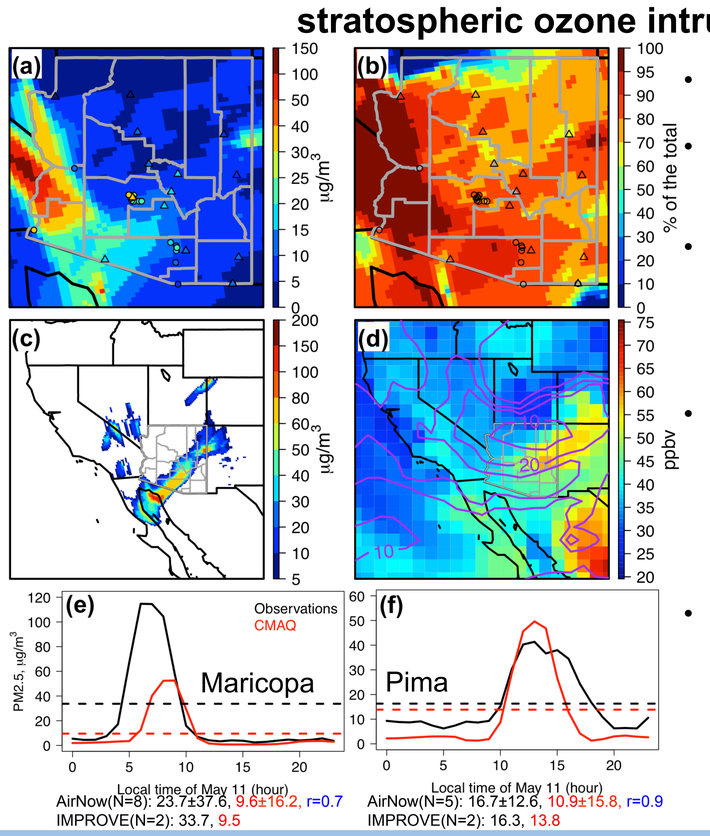


- AQS hourly extremes missing from IMPROVE
- AirNow data is timely available, IMPROVE data is delayed
- Inter-annual variability is overall associated with soil wetness
- Inconsistency exists among the these variables:
  - Different sample methods and densities
  - Particle size distributions depend on soil wetness



- Dust events selected by hourly AQS and meteorological data for 2007: these events were evaluated by correlating PM and AQS trace gas observations
- Dust events more often in the afternoon (drier soil, faster winds) – MODIS unable to capture dust storms at all times of the day, and we should expect hourly sampling from GEO- satellites in the future

4. Case study: a recent strong dust event accompanied by stratospheric ozone intrusion



- In general the timing is right at the AirNOW sites.
- At the daily maxima, model underpredited in Maricopa and overpredited in Pima.
- As for the 24h mean, the model underpredicted the magnitude at both counties, with more significant negative biases in Maricopa than in Pima
- Both model and observations show significant variability (e.g., standard deviations), indicating the advantages of using the AirNow data in order to capture the extreme events.
- Current system is unable to capture both ozone and PM nicely when stratospheric ozone intrusion and dust events concur, which happens at times in the WUS.

5. Conclusions and suggestions

- Hourly PM and met data captured some dusty periods missed from IMPROVE and MODIS satellite records: GEO- satellites will assist observing dust storm events
- Soil wetness/vegetation affected inter-annual variability of dust activity: Satellites assist with drought monitoring, which will help predicting future dust storm frequency
- NAQFC CMAQ system fairly well predicted recent strong dust storms: Improvement in the magnitude and timing is ongoing and satellite data will be incorporated (emission/ chemical data assimilation)