



Satellite-aided Regional Dust Forecasting for Valley Fever Surveillance, Highway Safety and Air Quality Management

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Project Information

Lead PIs: Daniel Tong (GMU), Orion McCotter (CDC),
Pius Lee (NOAA), and Jesse Bell (UNMC)

Stakeholders:

Jonny Malloy, ADEQ
Matthew Roach, ADHS
David Hadwiger, NM DOT
Scott Van Pelt, USDA ARS
Scott DiBiase, Pinal County AQCD
Beth Gorman, Pima County DEQ
Andy Edman, NWS
Jeff McQueen, NWS

Co-Investigators/Collaborators

Thomas Gill, UTEP
William Sprigg, SPC
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Zhong Liu, NASA/GSFC & GMU
Ziheng Sun, GMU
Robert Levy, NASA
Liping Di, GMU
Ralph Kahn, NASA
Nicolas Webb, USDA
Adrain Chappell, Cardiff University (UK)
Julian Wang, NOAA

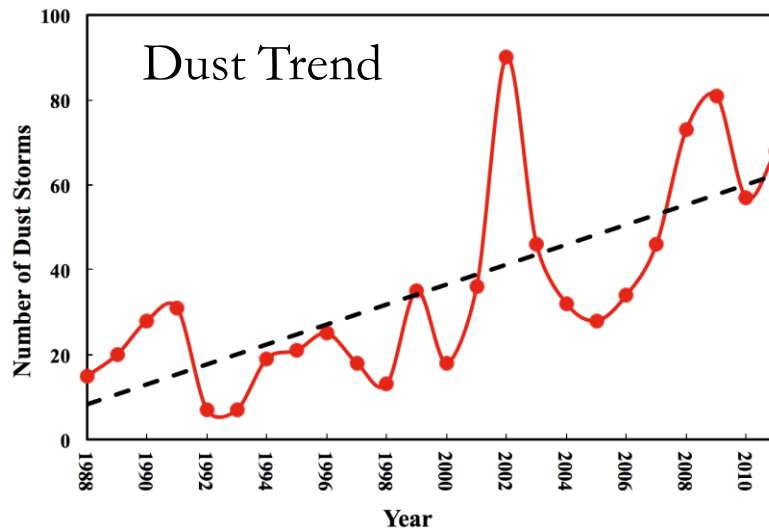
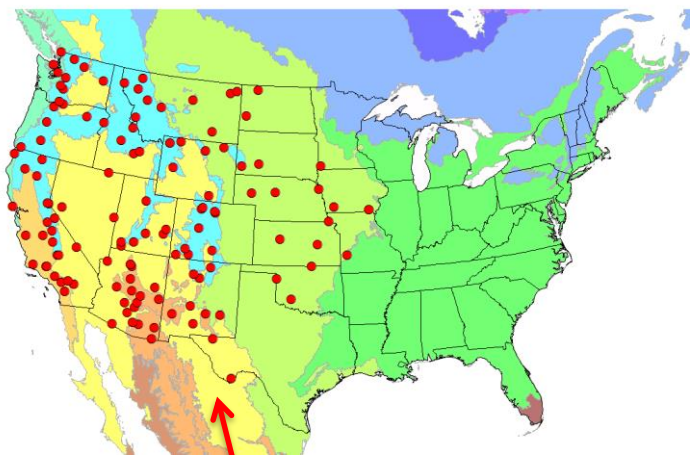
Project Period: 11/16/2018 – 11/15/2021

Budget: \$928K (\$309K in Y1)

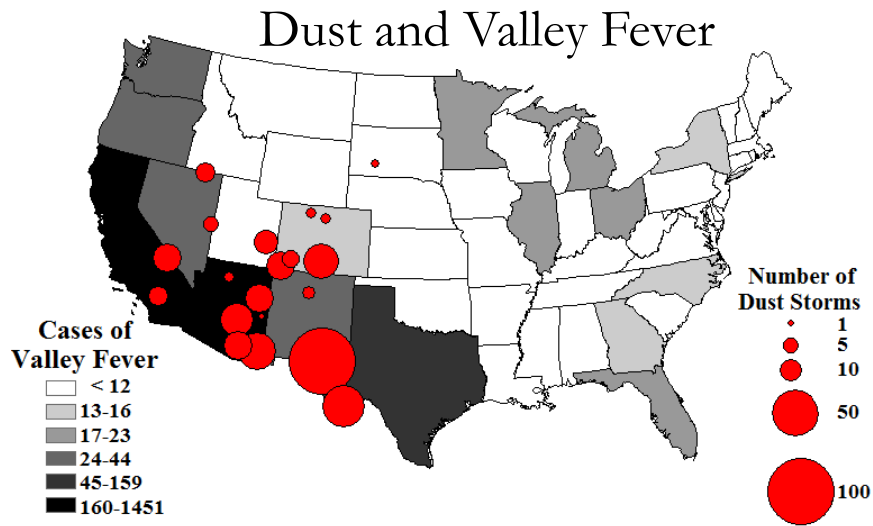
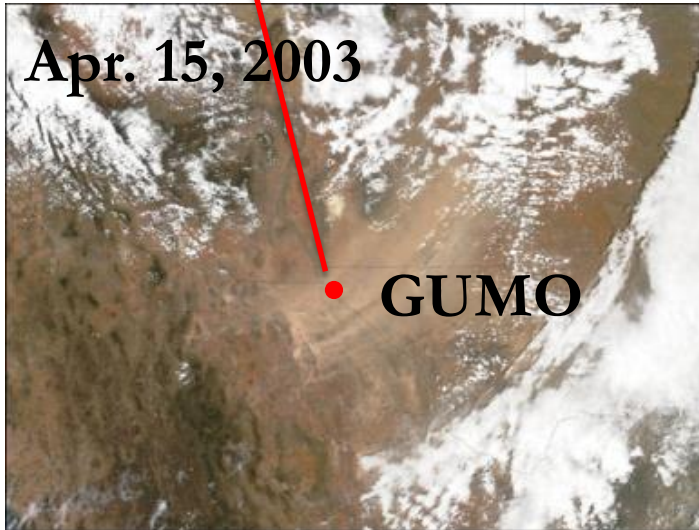
Rising Dust

(Source: Tong et al., GRL, 2017)

Ground Network



MODIS Dust



20 Large Storms per year in 1990s → 48 Storms in 2000s;

Highway Safety, Solar Energy, Agriculture...

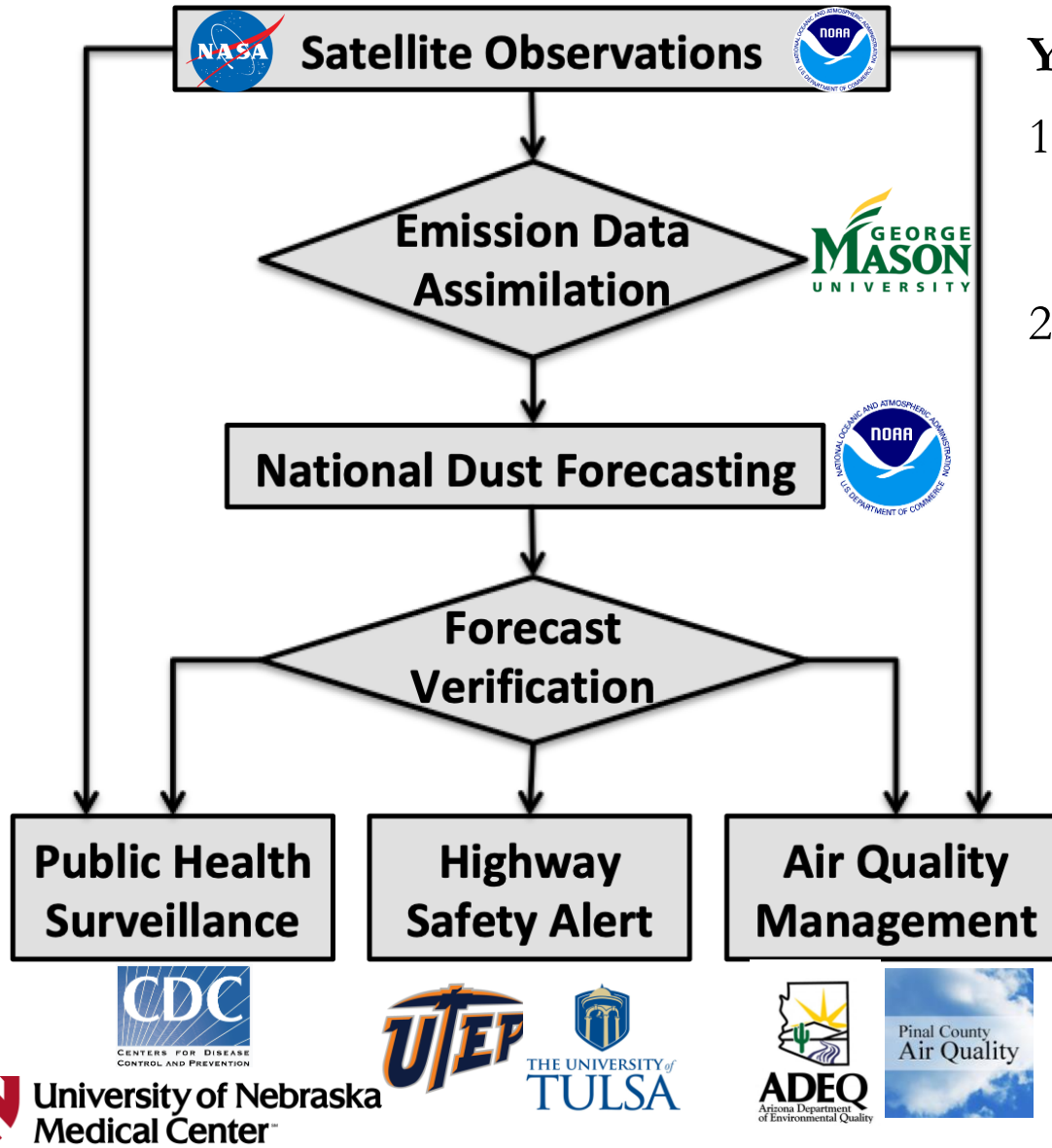
❖ Highway traffic accidents caused by visibility loss and high wind



❖ Dust deposition reduces power generation efficiency of solar farms



Satellite-aided Dust Forecasting

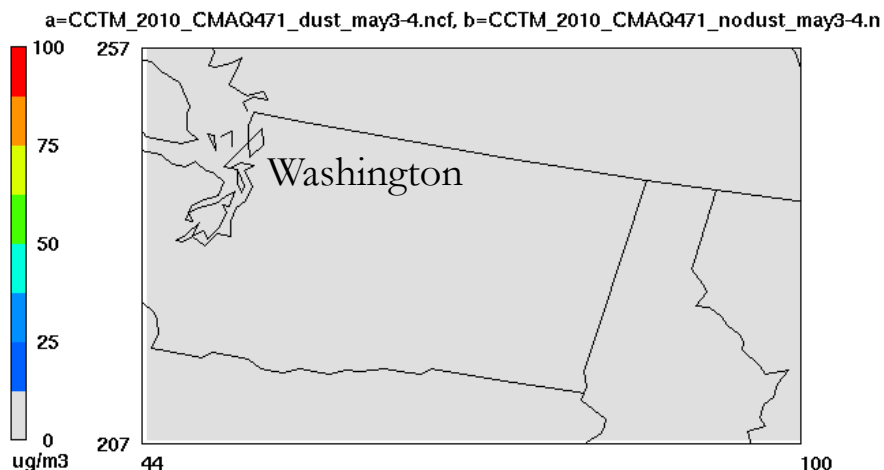


Year 1 Milestones:

1. Improve national dust forecasting with satellite land observations;
2. Support three dust services:
 - a) Valley fever surveillance;
 - b) Highway safety alert;
 - c) Air quality management;

Real-time Dust Storm Forecasting (FENGSHA)

Dust PM2.5 on May 3, 2010

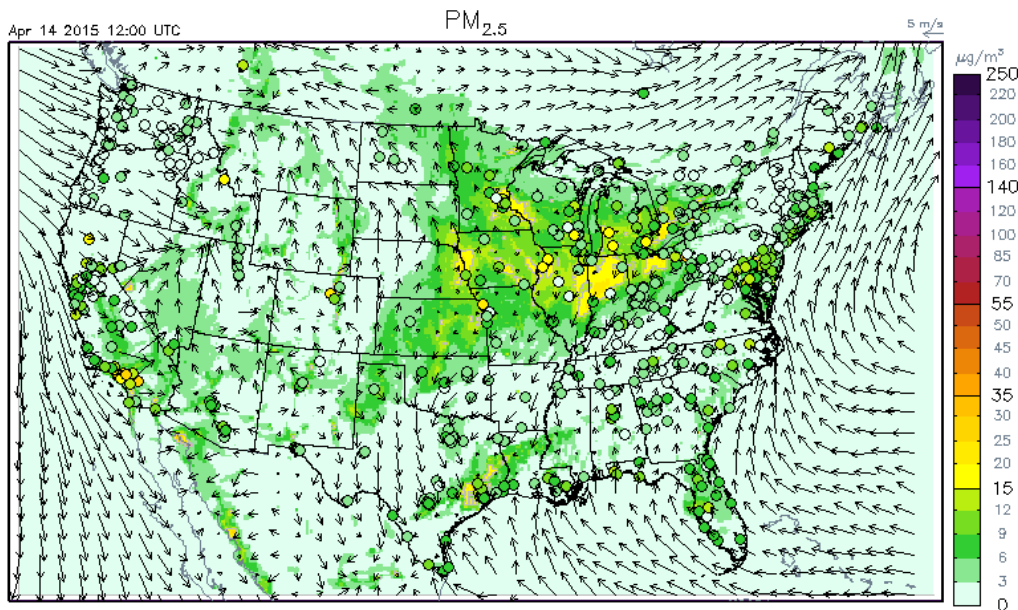


12:30 p.m, May 3, 2010



May 3, 2010 12:00:00
Min= -2 at (53,252), Max= 0 at (98,213)

--<http://earthobservatory.nasa.gov/NaturalHazards>



Dust storm killed two people on I-80.

(Courtesy of Hyuncheol Kim)

Dust Source Map in FENGSHA

Flux of Dust

Soil Erosion Potential

Surface Friction Velocity

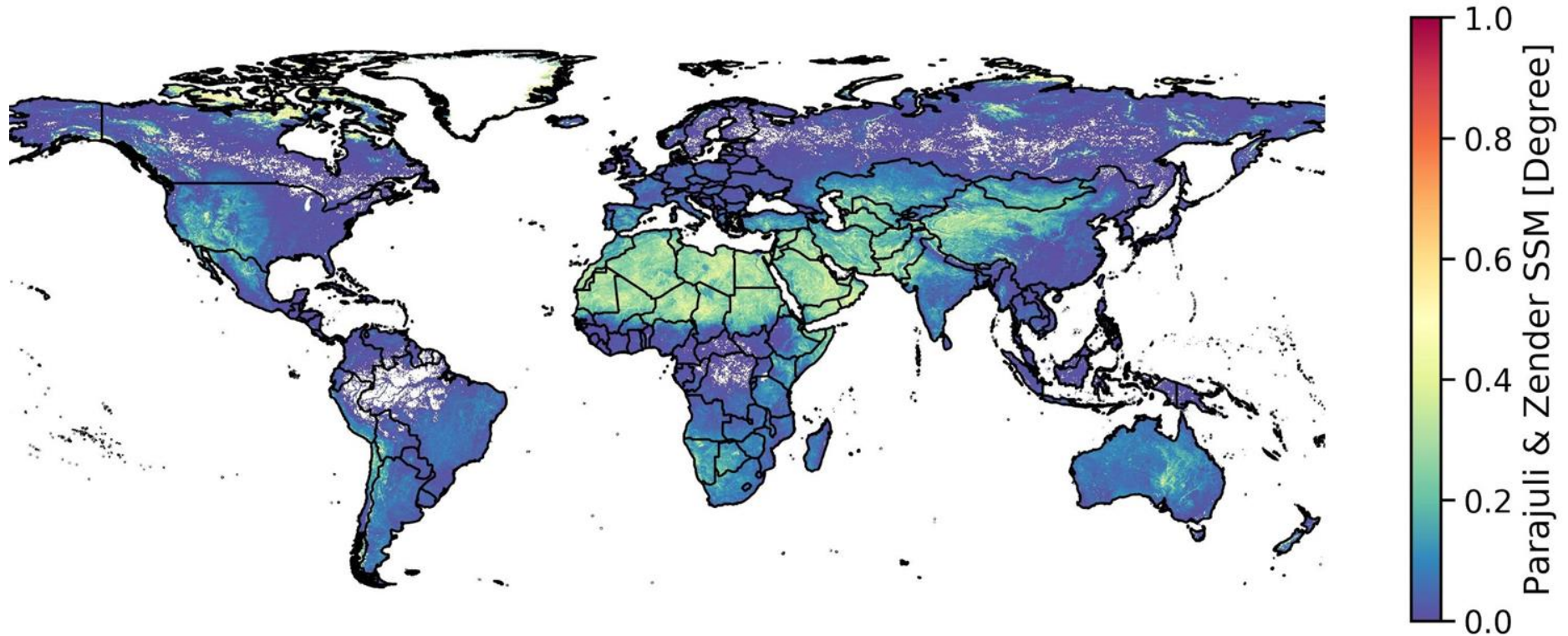
Surface Threshold Velocity

$$F = \alpha \times A \times S \times \frac{\rho}{g} u_{*T}^3 \left(1 - \left(\frac{u_{*t}}{u_{*T}} \right)^2 \right)$$

Vertical to Horizontal Flux Ratio

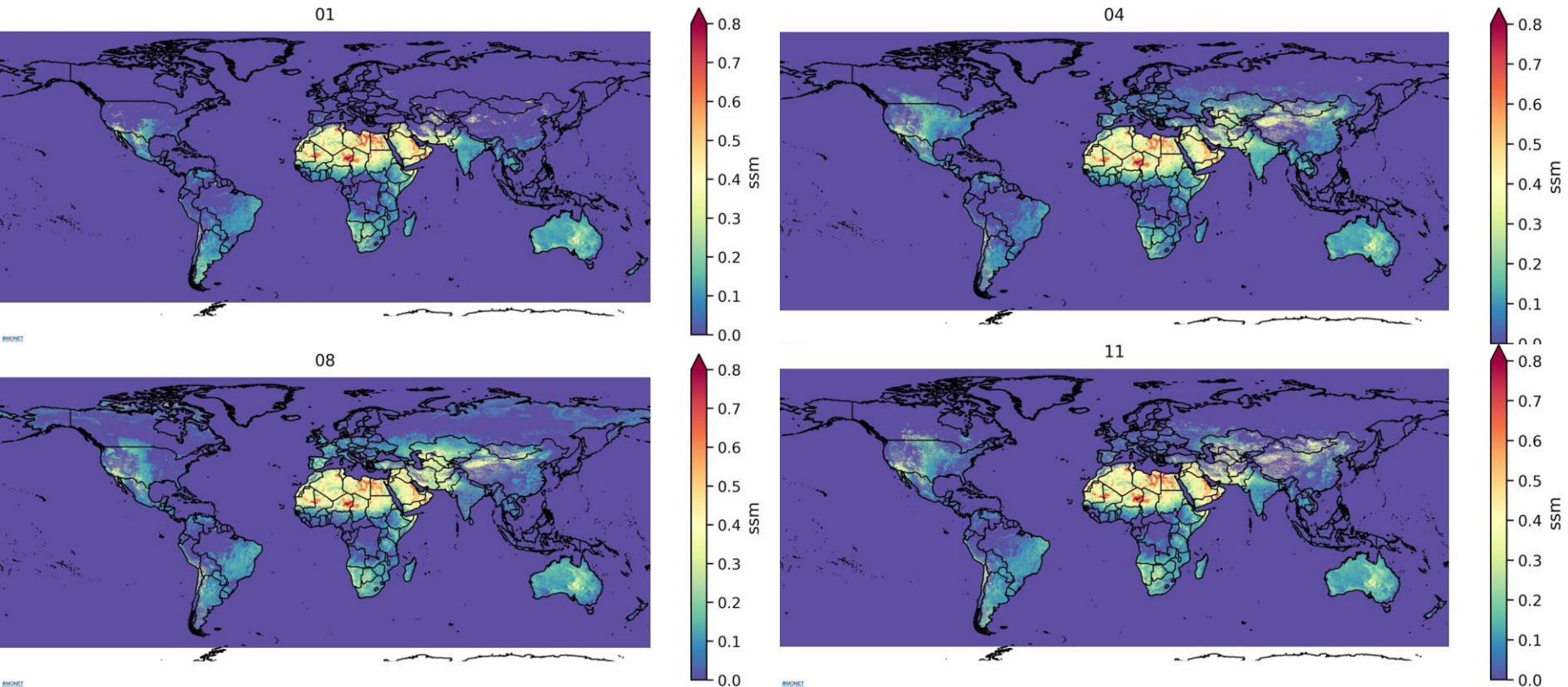
Dust Source

Horizontal Flux (Q)



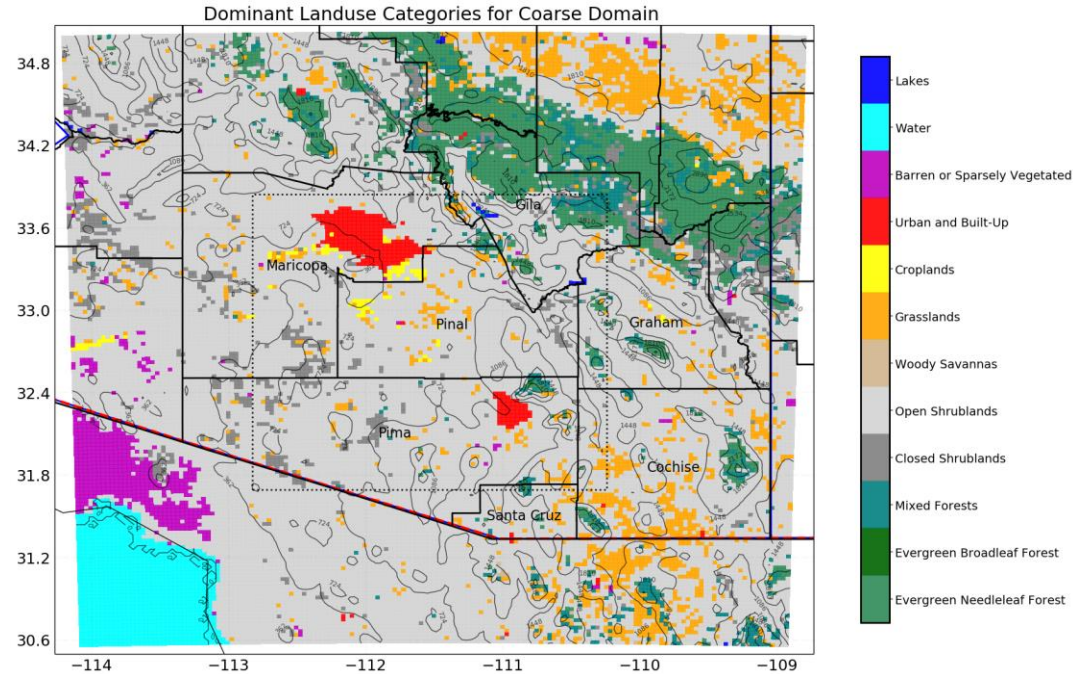
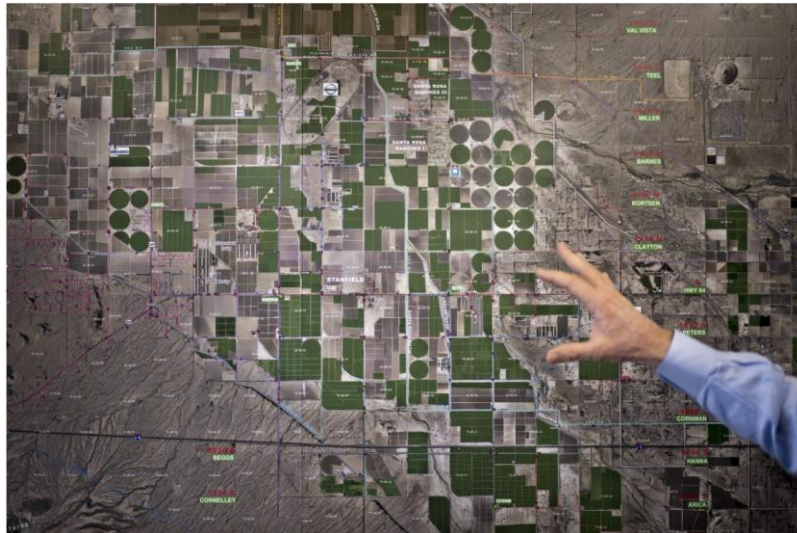
Dynamic Dust Source Map

- New source maps based on a revised Chappell and Webb method;
- It uses the normalized albedo to better describe the lateral cover heterogeneity;
- Monthly maps from 3 year climatology of the MCD43A3 MODIS BRDF Albedo'



What Happens if Water Is Cut off?

Water from Colorado River to be slashed > 60 percent in first 3 years of a shortage. After that, their supply of Colorado River water will be cut off.



40% of farms will not plant seeds;
Pinal County government asked to
provide high-resolution dust
forecasting for air quality management.

How Many People Were Killed by Dust Storms?

A Myth of Two Tales



Summary of Natural Hazard Statistics for 2017 in the United States



This National Weather Service (NWS) report summarizes fatalities, injuries and damages caused by severe weather in 2017. The NWS Office of Meteorology and Weather Services and the National Climatic Data Center compiled statistics from Storm Data, a report comprising statistics from NWS forecast areas, and the Virgin Islands.

6 killed in 25-vehicle pileup at New Mexico-Arizona line

UPDATED ON: JUNE 20, 2017 / 6:51 AM / AP



Weather Events, Fatalities, Injuries, and Damage Costs

Fatalities	Injuries	Property Damage (million \$)	Crop Damage (million \$)	Total Damage (million \$)
0	0	0.05	0.31	0.36
0	0	0.35	0.00	0.35
0	0	0.06	0.00	0.06

LORDSBURG, N.M. -- Authorities in New Mexico say six people are dead after a 25-vehicle pileup on I-10 was caused by sudden blowing dust in New Mexico near the Arizona state line.

“..six people dead after a 25-vehicle pileup”

Source: CBS News June 2017

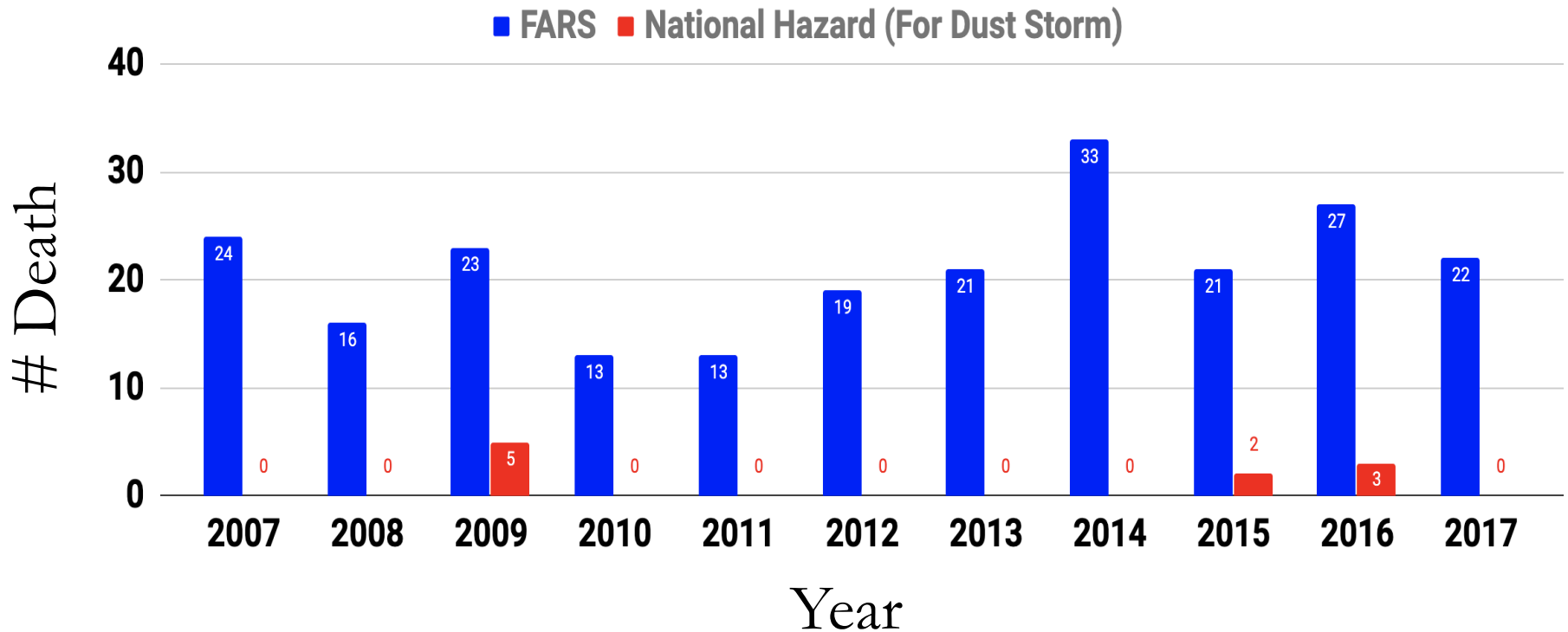
Source: <https://www.nws.noaa.gov/om/hazstats/sum17.pdf>

(Irene Feng)

A Lot of People Killed by Dust Storms!

FARS: Fatality Analysis Report System (FHA)

NHS: National Hazard Statistics (NOAA)



How did NHS go wrong?

- 1) Incomplete reporting system;
- 2) Mis-categorized statistics;

Citizen Science Platform for Dust: NASA GLOBE Observer

Working with NASA GLOBE Observer to launch a new citizen science campaign to collect dust observations (reports and photos).



NASA GLOBE Observer Contacts:

Marile Colon Robles: marile.colonrobles@nasa.gov

Helen Amos: helen.m.amos@nasa.gov

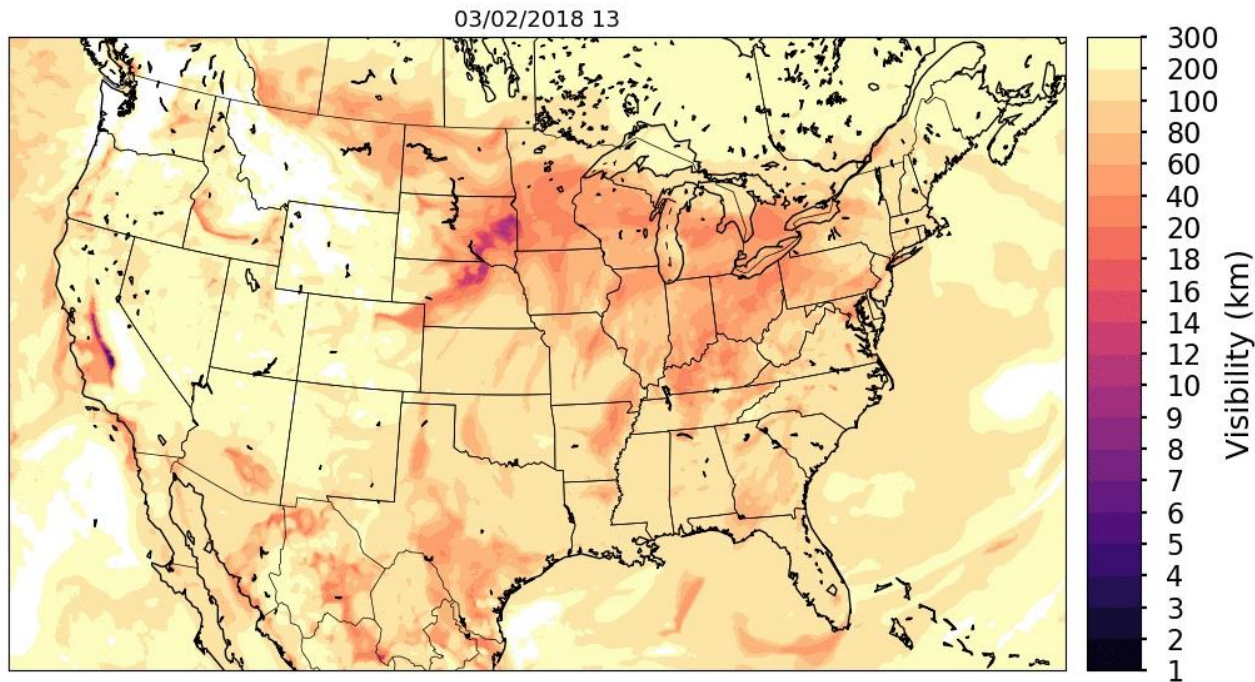
Stakeholders:

WMO Sand and Dust Regional Centers;
Transportation/Health/Air Quality Agencies;

DustWatch: App for Highway Safety

Highway dust forecasts:

- Visibility
- High Wind
- Dust Concentration
- Inhalable Particle Concentration



(Courtesy: Barry Baker)

DustWatch App:

- Citizen Scientist Project
- Use dust forecasts
- Real-time dust alerts



(Contact Dust App. Team:
dustapp2018@gmail.com)

Future Plan

Tasks	Months after Start					
	6	12	18	24	30	36
Task 1. Using NASA data to improve NAQFC dust forecasting						
a. Update dust map with MODIS land and aerosol products	█	█				
c. Use MODIS albedo to adjust surface roughness;		█	█	█		
d. Test new system in NAQFC with NASA observations (6);		█	█	█	█	█
e. Transition improved dust forecasts to NAQFC (8 or 9);		█	█	█	█	█
Task 2. Public health application: Valley fever surveillance						
a. Analyze long-term dust and incidence data;		█	█			
b. Test early warning system with NAQFC dust forecasts (6);				█	█	
c. Transition the early warning products (7-8);					█	
Task 3. Highway Accident Prevention						
b. Test/evaluate the integrated system at NMDOT sites (5);				█	█	
c. Deploy roadside dust alert capability (6);				█	█	
d. Transition the early warning products to NMDOT (8 or 9);				█	█	█
Task 4. Air Quality Management						
a. Support air quality forecasting and early warning (7);		█	█	█	█	█
c. System transition and user training workshop (9);					█	█

ARL and Risks

Application Readiness Level:

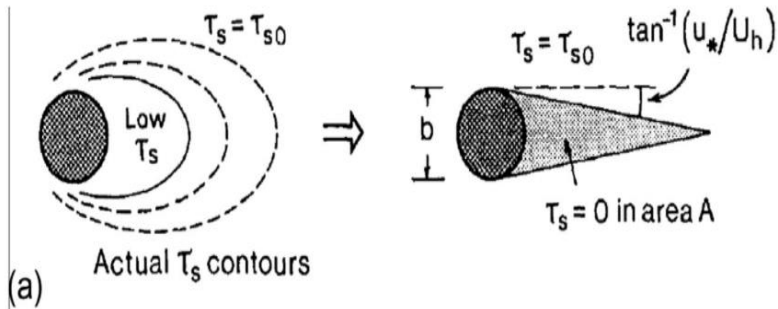
- 5-6 for the dust forecasting system (NWS);
- 5-6 for the highway warning system (NMDOT);
- 4 for Valley fever surveillance system (CDC);

Risks:

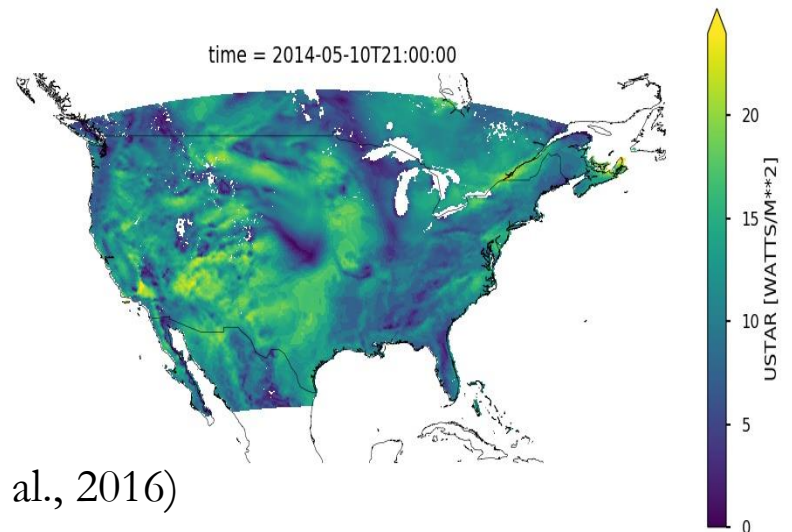
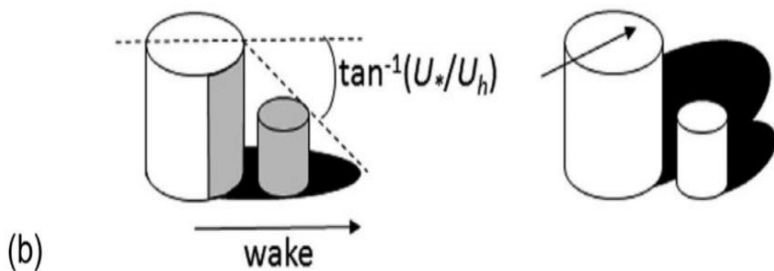
- Technical issues: Technical risks exist for each of the three systems; Some may not work out as expected;
- Operations challenges: NWS moving to a new forecasting system; Understaffed states and federal offices;
- Management challenges: Large team; Stakeholders doubled in the first year; May not be able to address additional requests (Farm level forecasting; Valley fever in Native Nations, WMO Dust Centers, etc).

Using Albedo to Improve Dust Forecasting

Use an albedo-based approximation of aerodynamic sheltering (L_w) to adjust surface roughness and dust emissions (Chappell et al., 2016).



$$\frac{u_{S*}}{U_f} = 0.0311 \left(\frac{e^{-\omega_{ns}^{1.131}}}{0.016} \right) + 0.007,$$

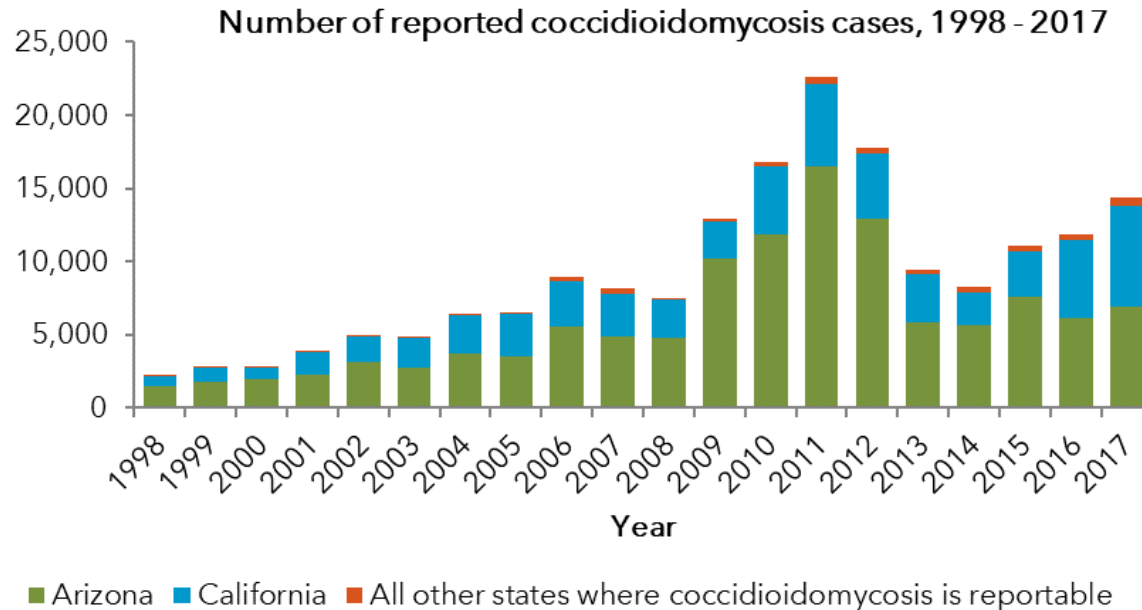


(Source: Chappell et al., 2016)

Burden of Disease

(Contributed by Orion McCotter and Jesse Bell)

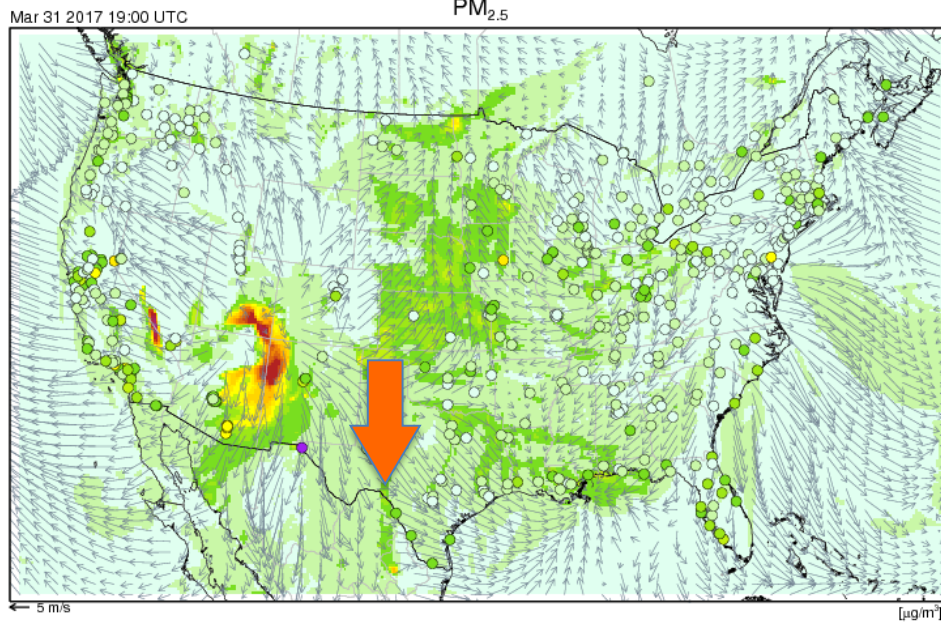
- Rates in the United States have increased dramatically
- ~10,000-20,000 cases reported to public health annually
- >95% of cases are from Arizona and California



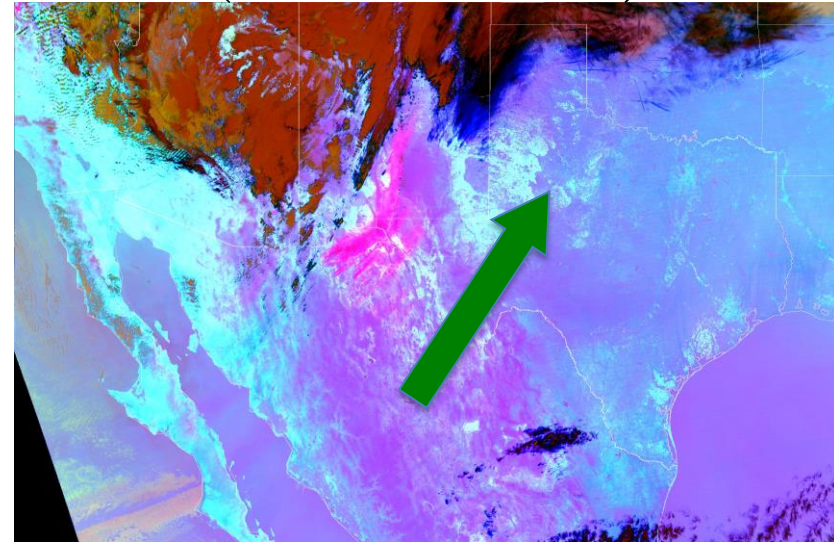
More reading: McCotter, O. Z. et al, 2019. Update on the epidemiology of coccidioidomycosis in the united states. *Medical Mycology*, 57 (Supplement_1), S30-S40.

Use VIIRS Dust to Evaluate Forecasts

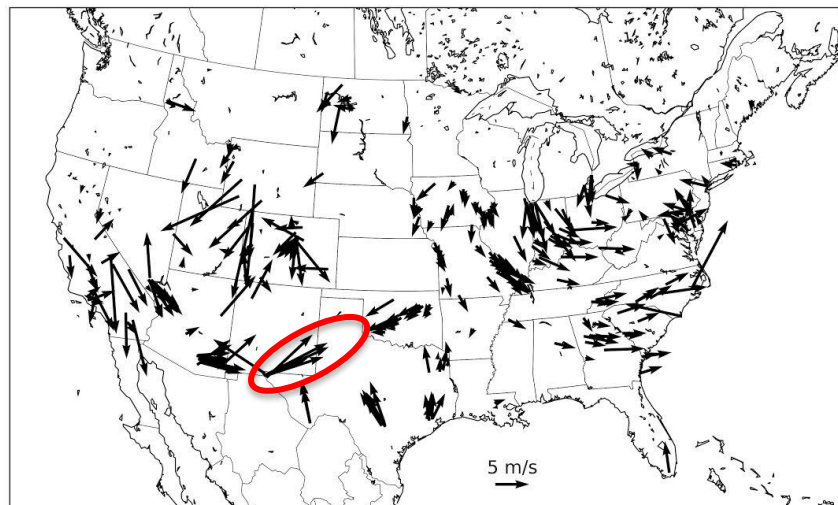
Northerly wind in El Paso, TX



Southwesterly Dust Plume (Suomi-NPP VIIRS)



Ground
observations
consistent with
satellite data



March 31 2017 Afternoon 19 UTC