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 Mc Cotter (Formerly CDC), Pius Lee (NOAA), and Jesse Bell (UNMC)

**Co-Investigators/Collaborators**
- Thomas Gill, UTEP
- William Sprigg, SPC
- Junran Li, University of Tulsa
- 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

**Stakeholders (New):**
- 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
- Dale Griffin, USGS
- Mariana Singletary, Pinal County DoH
- Alexander Baklanov, WMO
- Andrea Sealy, WMO Pan-America
- Michael Lewis, US Army ERDC
- Brooke Doman, NM DoH
- TuSimple (Autonomous Trucking)

10+ new ones added in 2021
Satellite-aided Dust Forecasting

Objectives:

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

• **Publications:** Eleven journal papers, Three in review; New “Dust and Health Review” under WHO & WMO.

• **Presentations:** 17 Presentations; 4 AGU/AMS sessions organized on GeoHealth and Air Quality;

• **Stakeholder meetings:** 12 small groups; Western US Dust Workshop;

• **Capability transfer:** National Weather Service albedo-based dust forecasting; Pima County air quality forecast advisory;

• **Media/Outreach:** 11 interviews and many republications; WMO news release; etc.
PM$_{2.5}$ Forecast during the March 15 Dust Storm

2021-03-16 12 UTC PM$_{2.5}$ (ug/m$^3$)
Capability Transfer: Albedo-based Dust Forecast

- FENGSHA dust code into NOAA operational models: GEFS-Aerosol, NAQFC CMAQ;
- Additional NOAA models: HYSPLIT and RAP-Chem; USFS and RRFS-CMAQ;
- NASA GOCART_v2 through NOAA-NASA joint venture;
- MODIS/VIIRS albedo and BRDF used for dust source map and drag partition.
Detecting Dust Microbes

**Objective:** Develop forecast capability of airborne microbes, including *Coccidioides*.

Laboratory Analysis (GMU/CDC)

**Soil and Dust Collection**

**Bacterial Genera**

[Map of Arizona showing Soil and Dust Collection sites]

[Graph showing Bacterial Genera with fold-change direction]
How Many People Were Killed by Dust Events on Highways? A Myth of Two Tales

The New York Times
8 Are Killed as Sandstorm in Utah Causes a Highway Pileup

Officials said 22 vehicles were involved in a crash after high winds created a sandstorm that limited visibility on Interstate 15. Some of those killed were children, the highway patrol said.

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

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.

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 Climate, Water and Weather Services and the National Climatic Data Center compiled the Summary of U.S. Natural Hazard Statistics from Storm Data, a report comprising statistics from NWS forecast offices in the 50 states, Puerto Rico, Guam, and the Virgin Islands.

Summary of 2017 Weather Events, Fatalities, Injuries, and Damage Costs

<table>
<thead>
<tr>
<th>Weather Event</th>
<th>Fatalities</th>
<th>Injuries</th>
<th>Property Damage (million $)</th>
<th>Crop Damage (million $)</th>
<th>Total Damage (million $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0.05</td>
<td>0.31</td>
<td>0.36</td>
</tr>
<tr>
<td>Drought</td>
<td>0</td>
<td>0</td>
<td>0.35</td>
<td>0.00</td>
<td>0.35</td>
</tr>
<tr>
<td>Dust Storm</td>
<td>0</td>
<td>0</td>
<td>0.06</td>
<td>0.00</td>
<td>0.06</td>
</tr>
<tr>
<td>Dust Devil</td>
<td>0</td>
<td>0</td>
<td>0.65</td>
<td>0.31</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Source: [https://www.nws.noaa.gov/om/hazstats/sum17.pdf](https://www.nws.noaa.gov/om/hazstats/sum17.pdf)
A Lot of People Killed by Dust Storms!

(Irene Feng, Thomas Gill & Kerstin Schepanski)

Three datasets:
NHS: Natural Hazard Statistics (NOAA)
Storm Data: Storm Event Dataset (NOAA)
FARS: Fatality Analysis Report System (DOT)

How did NHS go wrong?
1) Incomplete reporting;
2) Miscategorized statistics;

National Weather Service has changed their dust reporting system.
WHO/WMO Dust Health Review

A Joint Review by NASA Dust Team, WHO, PAHO, and WMO

➢ WHO Guidance for Medical Practitioners;
➢Submitted to Review of Geophysics;

Health and Safety Effects of Airborne Soil Dust in the Americas

Project Stakeholder Workshop

- Team up with stakeholder NM Dept. of Environ.
- Networks: HAQ Dust Team; Southern NM Symposium; Arizona Dust Workshop; WMO Sand and Dust Storms Warning Advisory and Assessment System (SDS-WAS); European COST inDust.
- 150+ registered participants;

SOUTHERN NM & WESTERN U.S. DUST SYMPOSIUM
October 25 – 27, 2021
Las Cruces, NM

The purpose of this symposium is to ultimately answer one question: “Are opportunities to apply dust research being missed?” Federal, state, and local agencies create policies for clean and healthy air, which benefit from both national and international research. However, difficulties arise in translating research results into policy. This symposium will attempt to bridge the gap between research and applications into policymaking that results in tangible public benefits. Topics on the agenda include dust and PM10 mitigation issues in Southern New Mexico and beyond; dust impacts on environmental quality, transportation safety, and public health; and the state-of-the-science in airborne dust research. This symposium focuses on windblown dust in the southwestern U.S. and North America, but with a global context.

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Outreach and Media Reports

A dozen interviews and numerous replications

Saving Lives by Predicting Dust Storm

In the southwestern United States, dust storms form suddenly, quickly reducing visibility to zero. No one wants to avoid these deadly hazards.

By Ingrid Bedard 13 December 2020

Tong's forecasting system, part of a larger project with the Applied Sciences program at NASA, will not only help reduce highway accidents but could also improve disease surveillance for valley fever and air quality management. "If we do things right," said Tong, "then we can save people's lives."

Scientists work to unravel fungus ecology as Valley fever expands throughout West

Dust Storms and Valley Fever in the American West

"We want to have a solution," said Daniel Tong, a NASA researcher and associate professor of atmospheric chemistry and aerosols at George Mason University. In 2017, Tong published a paper linking increased dust storm activity in Arizona to an increase in Valley fever cases.

Now, he is trying to capture fungus from dust in the air to potentially lay the groundwork for a warning system.

One of the major regional developments this year is the funding of a new ensemble dust forecasting project by the US National Aeronautics and Space Agency (NASA), in partnership with WMO SDS-WAS Pan American Center, WHO/Pan-American Health Organization, and several federal and local agencies, to provide real-time forecasts of dust storms and wildfires over North America. Although air quality continues to improve in this region, the threat posed by Valley fever remains strong.
ARL, Risks and Budget

Application Readiness Level:
• 6 for Valley fever surveillance system (CDC);
• 7 for the highway warning system (NMDOT);
• 9 for the dust forecasting system (NWS, Pima County);

Risks and Mitigation Strategies:
• Technical issues: Technical risks exist for health surveillance and transportation systems; Some may not work out as expected;
• Operations challenges: Staff changes in stakeholder offices; COVID-19 responses push everything else aside in health agencies.
• Management challenges: Large team; Stakeholders tripped; May not be able to address additional requests;
Backup Slides
Low-Cost Air Samplers

Marble Dust Collector (MDCO)  PurpleAir Air Quality Sensor

Big Spring Number Eight (BSNE)  Aspirated Air Sampler

(Contributed by Scott Van Pelt)
Satellite-Aided Dust Storm Forecasting

- Outer domain (12km): CONUS;
- Inner domain (3km): Southwest.

- Emission: EPA NEI2016 + Biogenic + Dust + Wildfires
- Meteorology: WRF4.1
- Full chemistry (CMAQv5.3.1) – capable of predicting general air quality ($O_3$, $NO_x$, CO, VOCs, PM);
- Satellite-aided prediction of extreme events: Dust Storms and Wildfires.
FENGSHA Dust Emission Model

- FENGSHA ("Windblown Dust" in Mandarin), initially developed at EPA based on measurements by Dale Gillette;
- FENGSHA emission algorithm:

\[
F = \sum_{i=1}^{M} \sum_{j=1}^{N} K \times A \times \frac{\rho}{g} \times S_i \times SEP \times u^* \times \left(u^2 - u^2_{*ti,j}\right)
\]

- Threshold friction velocity is further controlled by soil moisture and surface roughness.

- Special treatments for the Southwest domain:
  - Cropland updated with GMU/USDA CropScape dataset (30m);
  - Dust sources adjusted based on vegetation cover (MODIS NDVI);
  - Soil texture data from soilGrids (250m);
  - Roughness effect based on Darmenova et al. (2009).
Where Did Fatal Accidents Occur?

- 14-33 dust fatalities each year (2007-2017);
- 30% of top-ranking fatal accidents in Arizona;
- 60% of deadliest accidents along I-10.
Windblown Dust vs Other Weather Hazards

(Contributed by Irene Feng, Thomas Gill and Kerstin Schepanski)