Impacts of Climate Extremes to Interstate and Local Trucking Industry across New Mexico and Arizona

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End Users: New Mexico Department of Transportation; Mesilla Valley Trucking; Bureau of Land Management, Las Cruces Office; Jornada Experimental Range – National Wind Erosion Network; NOAA-NWS Albuquerque, Santa Teresa, Phoenix, and El Paso Weather Forecast Offices; Arizona Department of Transportation; NM Trucking Association

Additional Support: New Mexico Department of Transportation

Project Dates: 2018 - 2021

Summary of Impact

Improving understanding of dust storms: Regional drought conditions combined with thunderstorms and wind events create dust storms that reduce driver visibility and make driving hazardous. This project increased understanding about dust storms in the southwest which informed develop a dust storm warning system now in use by NOAA-NWS offices in El Paso, TX and Phoenix, AZ.

Strengthening connections: The project fostered collaboration between researchers, state transportation managers, and NOAA-NWS offices, strengthening connections and facilitating ongoing efforts to address dust storm challenges.

Informing warning systems, training, and dust mitigation: Findings informed New Mexico Department of Transportation's driver safety campaigns and installation of new road signs and driver warning systems. New Mexico State University and trucking companies incorporated project materials into driver training programs. Time-lapse imagery provided valuable insights into how native grasses can reduce dust emissions, contributing to knowledge about effective mitigation strategies.

Problem Statement

Transportation along U.S. highways forms a basis for the national economy, moves goods from place to place, and connects communities. Dust storms – caused by convective thunderstorms, wind, and exacerbated by drought – creates hazardous driving conditions. This issue is of particular concern near the Lordsburg playa, a dry lakebed in southwestern New Mexico.

Research Focus

This project aimed to understand dust events in southwestern New Mexico and use that information to inform driver education and dust storm early warning systems. Observation systems were developed to characterize and document the climatic and visual conditions that exist during dust storms.

Project Activities

Fieldwork: Placing time lapse cameras and sensors to monitor dust and data collection.

Analysis: Ongoing monitoring and analysis of the time lapse footage, including piloting machine learning analysis.

Student training: Training on data collection and analysis and synthesizing findings for public outreach.

Application of findings: Assisting agencies to characterize and document climatic and visual conditions during dust storms through dash camera footage from drivers.

Stakeholder engagement: Active, continuous engagement with end users and partners through email, phone calls, interviews, workshops, presentations, social media, and materials for education and training.

Project Outputs

Presentations:

Southern New Mexico Fugitive Dust Symposium and Workshop. 2019. Las Cruces, NM.

Observations of windblown dust transportation hazards along I-10 using a network of sensors. 2019. American Meteorological Society Annual Meeting.

Let's talk about dust and mesonets! 2020. National Weather Service Annual Science and Operations Officer workshop, Santa Teresa, NM.

The Flavors of Dust Storms Across the Southwestern US. 2020. Southern New Mexico Dust Conference, Las Cruces, NM.

Dust events on the Lordsburg playa based on time-lapse camera imagery in 2020 and 2021. 2021. Southern New Mexico & Western U.S. Dust Symposium. New Mexico Environmental Department, National Aeronautics and Space Administration.

Summary of Dust Storms in the Spring 2022. 2022. Southern New Mexico & Western U.S. Dust Symposium. New Mexico Environmental Department, National Aeronautics and Space Administration.

Report:

DuBois, D. 2022. Dust Mitigation Monitoring Project, Final Report. Prepared for the Research Bureau New Mexico Department of Transportation, Albuquerque, NM.

Etyemezian V., G. Nikolich, D. DuBois, M. DeAntonio, J. Fuentes, Z. Ghodsi Zadeh, O. Nayares, S. Engle. 2018. Early Warning Sensor Network for Brown-out Conditions: Pilot

implementation on I-10. Final Report. Prepared for SOLARIS Consortium, Tier 1 University Transportation Center, Center for Advanced Transportation Education and Research, Department of Civil and Environmental Engineering, University of Nevada, Reno.

Master's Theses:

Fuentes, J. 2019. Using time-lapse footage to estimate mineral dust concentrations at heights correlating to passenger and commercial vehicles. MS Thesis. New Mexico State University.

Gutierrez, J. 2020. Automated detection of dust storms from ground-based weather station imagery using neural network classification. MS Thesis. New Mexico State University

Media Coverage:

NOAA RISA's CLIMAS Team: Science Clears the Air in Dust Storm Response. 2018. Video created by NOAA Climate Program Office. https://youtu.be/ENylO-coRKg

Highlighted in the 2019 NOAA Science Report. 2020. G. Digiantonio, E. Kelley, E. Bayler, N. Christerson, S. Davis, K. Dreflak, J. Hameedi, M. Liddel, G. Matlock, L. Newcomb, J. Roberts, P. Roohr. NOAA Silver Spring, Maryland, p. 40.

Selected Scientific Findings:

Visibility: Visual and instrumental data supported the hypothesis that commercial trucks have better visibility in dust storms than passenger vehicles, due to the seat height and view of drivers. However, dust concentration can differ at various heights, so visibility does not *always* improve with increased seat height.

Dust concentration patterns: Generally, there are higher concentrations of dust closer to the ground (1 meter) than higher up (3 meters). Gravity pulls dust particles downwards, making it harder for them to stay suspended in the air at greater heights. But wind and air currents also affect dust concentration. Dispersion - how wind and air spread dust particles – can sometimes lead to higher dust concentrations at 3 meters than at 1 meter.

Effect of air conditions on dust: Observations of dust emissions in southwestern NM show complexity and the importance of vertical motion and convection in the dispersion of dust plumes. Turbulent updrafts of air, caused by unstable air conditions due to uneven heating and wind patterns, can lift dust particles to higher elevations.

Effect of thunderstorms: Convective dust events, triggered by thunderstorms, can occur quickly without much warning and can cause a lot of damage. Summertime convection often occurs over the Gila or Chiricahua Mountains and can spark growth of storms by upslope forced convection.

Using dust early warning systems; Early warning dust forecast systems could potentially minimize the number of vehicle accidents and associated fatalities on New Mexico highways. However, driver behavior is also important. Education about driving during dust storms is also necessary to increase driver safety.

Using machine learning to classify dust storms: A system developed through this project used machine learning with time-lapse camera images to classify dust storms by analyzing characteristics like hue, saturation, and value bands. The system proved highly effective, achieving 97% accuracy and 94% precision in classifying dust storms.

Leveraged Funding

Supporting this project:

- New Mexico Department of Transportation - ($175,000)

Societal Impacts by Category

Conceptual:

- New Mexico Department of Transportation used findings about driver visibility in campaigns about dust storms and highway safety practices, such as the Take 5 Stay Alive campaign.
- Public awareness about dust storms, transportation hazards, and research findings occurred through social media campaigns and messaging via local news and NWS offices in Albuquerque and El Paso.
- Time-lapse imagery increased understanding about how areas seeded with native grasses can reduce soil erosion and dust emissions.

On raising awareness:

Through this [interaction with CLIMAS] we were able to quickly build up a level of knowledge about dangers in the area and the frequency of dust storms.

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Trent Botkin, New Mexico Department of Transportation

Connectivity:

- This project stemmed from connections made with state transportation managers and NOAA-NWS offices at a dust workshop in 2015 and continued engagement with local and interstate freight and trucking operators in AZ and NM.
- Dave Dubois continues to expand the network of potential end users by providing information to help install visibility sensors to detect dust storms throughout Arizona and New Mexico.

Capacity Building:

- Graduate and undergraduate students at New Mexico State University gained experience with quantitative data collection and analysis. Two students completed master's theses directly related to this project.

- New Mexico State University used CLIMAS research on dust storms to make a new module for the University's vehicle training program. Every person driving a university vehicle must pass this module about what to do during a dust storm
- Trucking companies used project materials to inform driver training programs.

Instrumental:

- This project provided scientific evidence to support development of a convective dust storm warning system that is used by the El Paso, TX and Phoenix, AZ Weather Forecast Offices.
- The New Mexico Department of Transportation used research findings to install new equipment to monitor dust conditions in southwestern NM. They also installed new signs and systems to alert drivers of hazardous road conditions.