AQRP Monthly Technical Report

PROJECT TITLE	Characterization of international and domestic sources of windblown dust and contribution to fine and coarse particulate matter in Texas	**PROJECT #**	26-007
PROJECT PARTICIPANTS	Daniel Tong, Siqi Ma, Chang Shu	**DATE SUBMITTED**	October 19, 2026
REPORTING PERIOD	**From:** Project Start **To:** September 31, 2026	**REPORT #**	1

A Financial Status Report (FSR) and Invoice will be submitted separately from each of the Project Participants reflecting charges for this Reporting Period. I understand that the FSR and Invoice are due to the AQRP by the 15th of the month following the reporting period shown above.

Detailed Accomplishments by Task for reporting period

Task 1.1 – IMPROVE dust observations

Long-term observations from the Interagency Monitoring of Protected Visual Environments (IMPROVE) network were compiled and evaluated for the 1988–2025 study period. The availability and record length of monitoring sites were assessed to establish a consistent network suitable for conducting long-term trend analysis. A total of 6 IMPROVE sites with records spanning the full study period. These six sites include GRSA1, MEVE1, WEMI1, BAND1, BIBE1, and GUMO1 (Table 1).

Table 1. Locations and site information of the six long-term IMPROVE sites for 1988–2025.

Site	Code	Latitude, Longitude	Elevation (m)	State
Great Sand Dunes	GRSA1	37.7249, -105.5185	2498	Colorado
Mesa Verde NP	MEVE1	37.1984, -108.4907	2172	Colorado
Weminuche Wilderness	WEMI1	37.6594, -107.7999	2750	Colorado
Bandelier NM	BAND1	35.7797, -106.2664	1988	New Mexico
Big Bend NP	BIBE1	29.3027, -103.1780	1066	Texas
Guadalupe Mountains NP	GUMO1	31.8330, -104.8094	1672	Texas

In addition, we have compiled another set of IMPROVE sites, with 16 stations covering the period of 2002-2025. Many of these sites do not have recorded before 2002. We use these two sets of sites to test if the choices of site number and study period influence the dust trends. These 16 IMPROVE sites include six sites in Colorado, seven in New Mexico, one in Oklahoma, and two in Texas.

Initial processing and dust event identification were performed using particulate matter (PM) and fine soil information available from the IMPROVE network following Shu and Tong, 2026. Annual dust event occurrence and PM concentrations were analyzed to characterize temporal variability and provide an initial assessment of long-term dust behavior.

Record shows that 2002 was an unusually dusty year, with an annual dust-event frequency of approximately 4.10%, the highest value during 1988–2025 (Figure 1). Dust event frequency was also elevated in 2003 at approximately 2.34%. Because these high-dust years occur at the beginning of the primary 2002–2025 study period, they may influence the estimated long-term trend. To evaluate this sensitivity, trend estimates were compared for the six-site network over 1988–2025, the same six sites over 2002–2025, and the full 16-site network over 2002–2025 (Table 2).

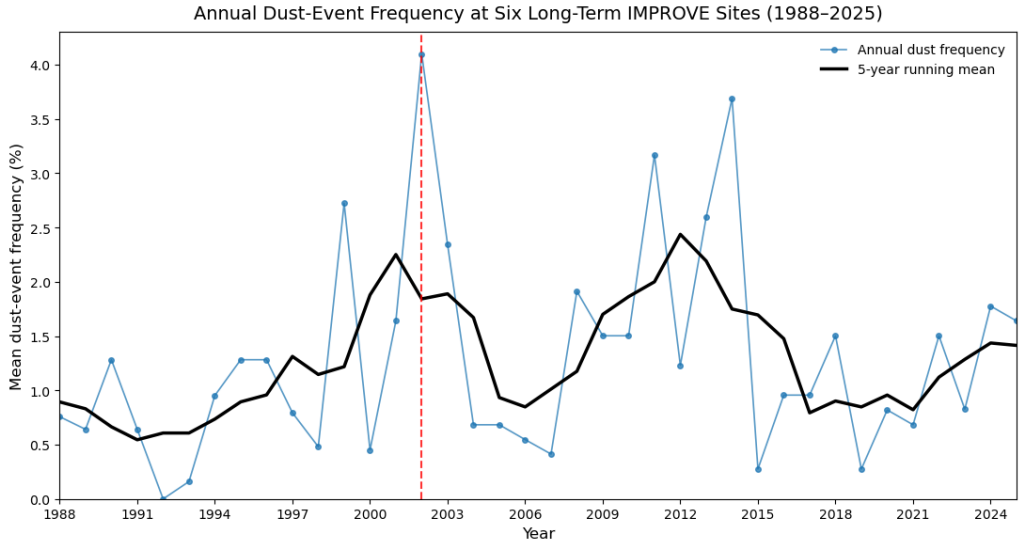

Figure 1. Annual dust event frequency at the six long-term IMPROVE sites during 1988–2025. The blue line shows annual mean frequency, and the black line shows the five-year running mean. The red dashed vertical line marks 2002.

For the six long-term IMPROVE sites over 1988–2025, the Poisson regression yielded an incidence rate ratio (IRR) of 1.010 (95% CI: 0.994~1.026; p = 0.219), indicating an estimated increase of approximately 1% per year in dust-event occurrence. The corresponding Theil–Sen slope was 0.012 per year (95% CI: −0.008~0.035; p = 0.151). Although both estimates suggest a weak positive tendency over the full 38-year record, neither is statistically significant because the confidence intervals include the null values of 1.0 for the IRR and zero for the Theil–Sen slope (Table 2). In contrast, restricting the same six sites to 2002–2025 changes the estimated trend direction: the Poisson IRR decreases to 0.977 (95% CI: 0.941~1.014), corresponding to an estimated decline of approximately 2.3% per year, while the Theil–Sen slope becomes negative (−0.018; 95% CI: −0.090~0.041). The full 16-site network over 2002–2025 produces estimates much closer to no trend, with an IRR of 0.999 and a Theil–Sen slope of 0.011.

To assess whether the estimated dust trend depends on the selected start year, a sensitivity analysis was performed by changing the beginning of the record and recalculating the Poisson IRR (Figure 2). A trend is statistically significant when its 95% confidence interval excludes the null value of

1. None of the analyses beginning before 2002 yielded a statistically significant trend. Starting in 2002 produces one of the more negative trend estimates, reflecting the influence of unusually high dust occurrence near the beginning of that period. However, extending the record to 1988 yields only a weak, statistically insignificant positive trend. Thus, the direction and magnitude of the estimated trend are sensitive to the selected analysis period, and no consistent monotonic trend emerges across start years.

Site-specific Poisson regressions were performed for the 16 IMPROVE sites to examine spatial differences in dust-event trends during 2002–2025 (Figure 3). The results reveal substantial heterogeneity in trend direction. Most Colorado sites show negative or near-zero estimates, with Mesa Verde (MEVE1) exhibiting a statistically significant decrease of approximately 7.8% yr^{-1} ($p = 0.017$). In contrast, Wichita Mountains, Oklahoma (WIMO1), shows an estimated increase of approximately 7.8% yr^{-1} ($p \approx 0.030$). New Mexico exhibits considerable within-state variability, with negative, near-zero, and positive estimates; Salt Creek Wilderness (SACR1) shows a statistically significant increase of approximately 4.2% yr^{-1} ($p \approx 0.030$). The two Texas sites show little evidence of a long-term trend, with estimates near zero or slightly negative.

Table 2. Comparison of long-term dust-event frequency trends under different monitoring-network and analysis-period definitions. Poisson incidence rate ratios (IRRs) and Theil–Sen slopes are reported with 95% confidence intervals.

Network / period	Poisson IRR (95% CI)	Poisson p	Theil–Sen slope (95% CI)	Theil–Sen p
6 sites, 1988–2025	1.010 (0.994, 1.026)	0.219	0.012 (−0.008, 0.035)	0.151
6 sites, 2002–2025	0.977 (0.941, 1.014)	0.225	−0.018 (−0.090, 0.041)	0.654
16 sites, 2002–2025	0.999 (0.970, 1.028)	0.927	0.011 (−0.032, 0.042)	0.655

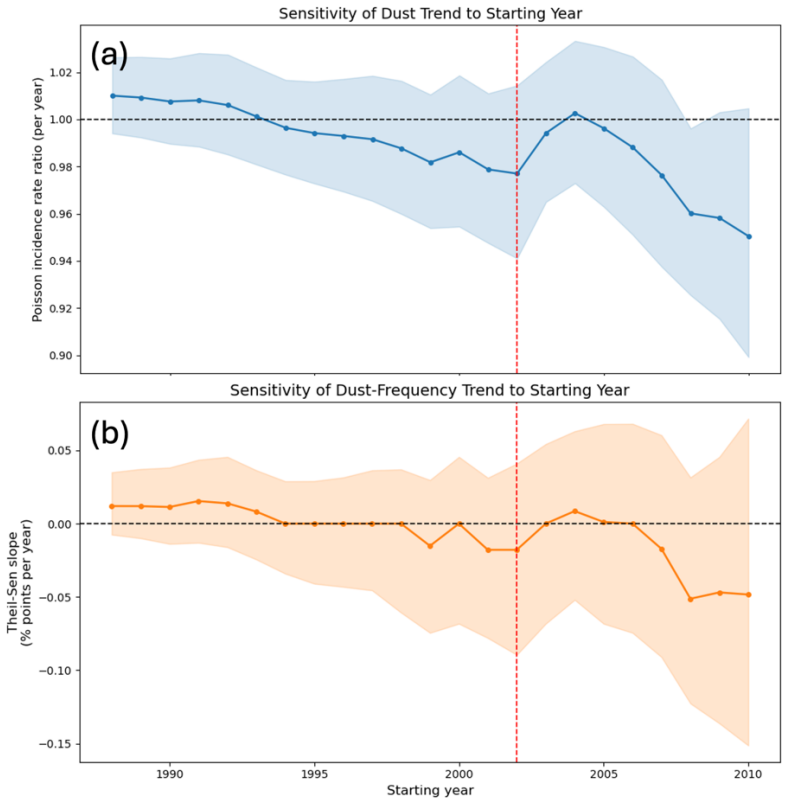

Figure 2. Sensitivity of estimated dust-event trends to the selected starting year for the six long-term IMPROVE sites. (a) Poisson incidence rate ratio (IRR) and 95% confidence interval. (b) Theil–Sen slope and 95% confidence interval. Horizontal reference lines indicate no trend, and the vertical dashed line marks 2002.

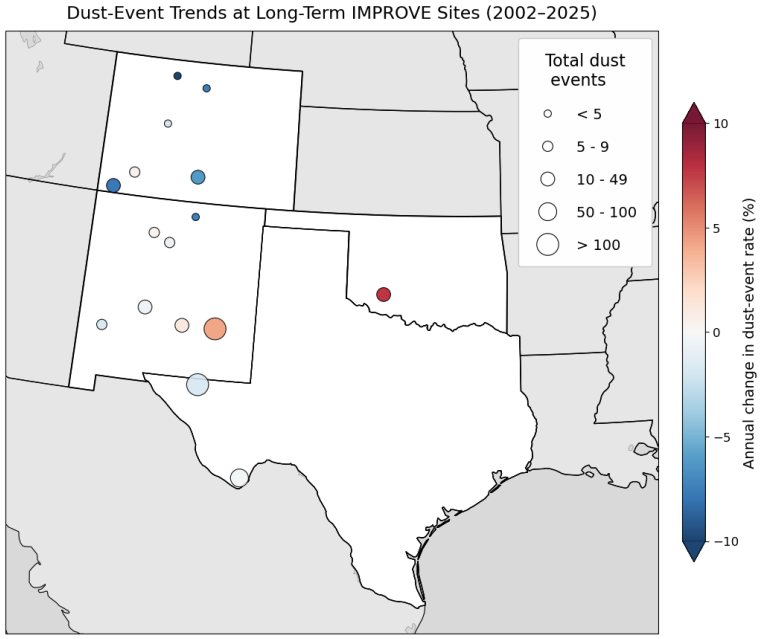

Figure 3. Site-level Poisson-estimated dust-event rate trends at 16 long-term IMPROVE sites during 2002–2025. Color indicates annual change in dust-event rate, and marker size indicates the total number of identified dust events.

Data Collected

During the reporting period, the project team assembled or initiated processing of the major observational datasets required for Task 1:

- IMPROVE particulate matter and mineral-dust observations covering the long-term study period;
- TCEQ $PM_{2.5}$ and PM_{10} monitoring information and observations for Texas; and
- NOAA ISD station metadata and meteorological observations needed for weather-based dust event identification.

Identify Any Problems or Issues Encountered and Proposed Solutions or Adjustments

No major technical or administrative problems were encountered during the reporting period.

Differences in monitoring duration, data completeness, and measurement availability among observational sites require careful screening before long-term trends can be calculated. A consistent set of long-term IMPROVE sites has therefore been established, while TCEQ and ISD stations are being screened according to temporal coverage and availability of the measurements required for dust identification. These data screening procedures will help reduce potential biases caused by changes in monitoring-network composition over time.

Goals and Anticipated Issues for the Succeeding Reporting Period

During the next reporting period, the project team plans to:

1. Continue quality control and refinement of the IMPROVE dust-event dataset and long-term trend analysis.
2. Continue processing TCEQ PM observations and begin systematic identification of dust events at selected Texas monitoring locations.
3. Complete screening of NOAA ISD stations based on record length and availability of wind, visibility, and present-weather observations.
4. Begin reconstructing dust events from the selected ISD stations.
5. Begin evaluating consistency among the observational datasets in preparation for subsequent intercomparison of long-term dust activity.

Detailed Analysis of the Progress of the Task Order to Date

The project is progressing according to the approved schedule. Work to date has focused on Task 1, including establishment of a consistent long-term IMPROVE monitoring network, initial reconstruction and statistical analysis of dust-event occurrence, assessment of TCEQ particulate matter monitoring locations, and preliminary preparation of NOAA ISD observations.

Initial IMPROVE analyses provide a preliminary characterization of spatial and temporal variability in dust activity, while TCEQ and ISD data preparation is underway. These activities provide the observational foundation required for later comparison of dust records, analysis of environmental drivers, and selection of representative high- and low-dust periods for modeling.

Do you have any publications related to this project currently under development? If so, please provide a working title, and the journals you plan to submit to.

☐**Yes** ☒ **No**

Do you have any publications related to this project currently under review by a journal? If so, what is the working title and the journal name? Have you sent a copy of the article to your AQRP Project Manager and your TCEQ Liaison?

☐ **Yes** ☒ **No**

Do you have any bibliographic publications (ie: publications that cite the project) related to this project that have been published? If so, please list the reference information. List all items for the lifetime of the project.

☐ **Yes** ☒ **No**

Do you have any presentations related to this project currently under development? If so, please provide working title, and the conference you plan to present it (this does not include presentations for the AQRP Workshop).

☐ **Yes** ☒ **No**

Do you have any presentations related to this project that have been published? If so, please list reference information. List all items for the lifetime of the project.

☐ **Yes** ☒ **No**

Have any personnel changes occurred that were not listed in the original proposal? If so, please include a detailed description of the personnel change(s) below.

☐ **Yes** ☒ **No**

Are any delays expected in the progress of the research? If so, please include a detailed description of the potential delay below.

☐ **Yes** ☒ **No**

Describe any possible concerns/issues (technical or non-technical) that AQRP should be made aware of.
None

Are you anticipating using all the available funds allocated to this project by the end date? If not, why and approximately what is the amount to be returned?

☒ **Yes** ☐ **No**

Submitted to AQRP by
Daniel Tong

References

Shu, C., & Tong, D. (2026). Three-decade dust climatology and trend (1988–2022) from ground monitoring over the western United States. Journal of Geophysical Research: Atmospheres, 131, e2025JD045878. https://doi.org/10.1029/2025JD045878