Low-cost $PM_{2.5}$ Measurements In A Binational Metropolitan Area Along The U.S.-Mexico Border

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Air Quality Context

- Paso delt Norte region faces frequent $PM_{2.5}$ and NO_2 Episodes
- Drivers: Desert dust, traffic, industry
- Limited regulatory monitors

$PM_{2.5}$ Source	Examples in Region	Estimated Contribution
Dust from Soil & Unpaved Roads	Windblown desert dust; vehicles on dirt roads	~70–80% (majority of $PM_{2.5}$ emissions)
Vehicle Emissions & Traffic	Diesel trucks at border crossings; high-volume highways; idling vehicles	~15–20% (largest human-caused source)
Industrial/Other Area Sources	Brick kiln clusters; factories and plants; construction dust; burning activities	<10% (combined minor contributions)

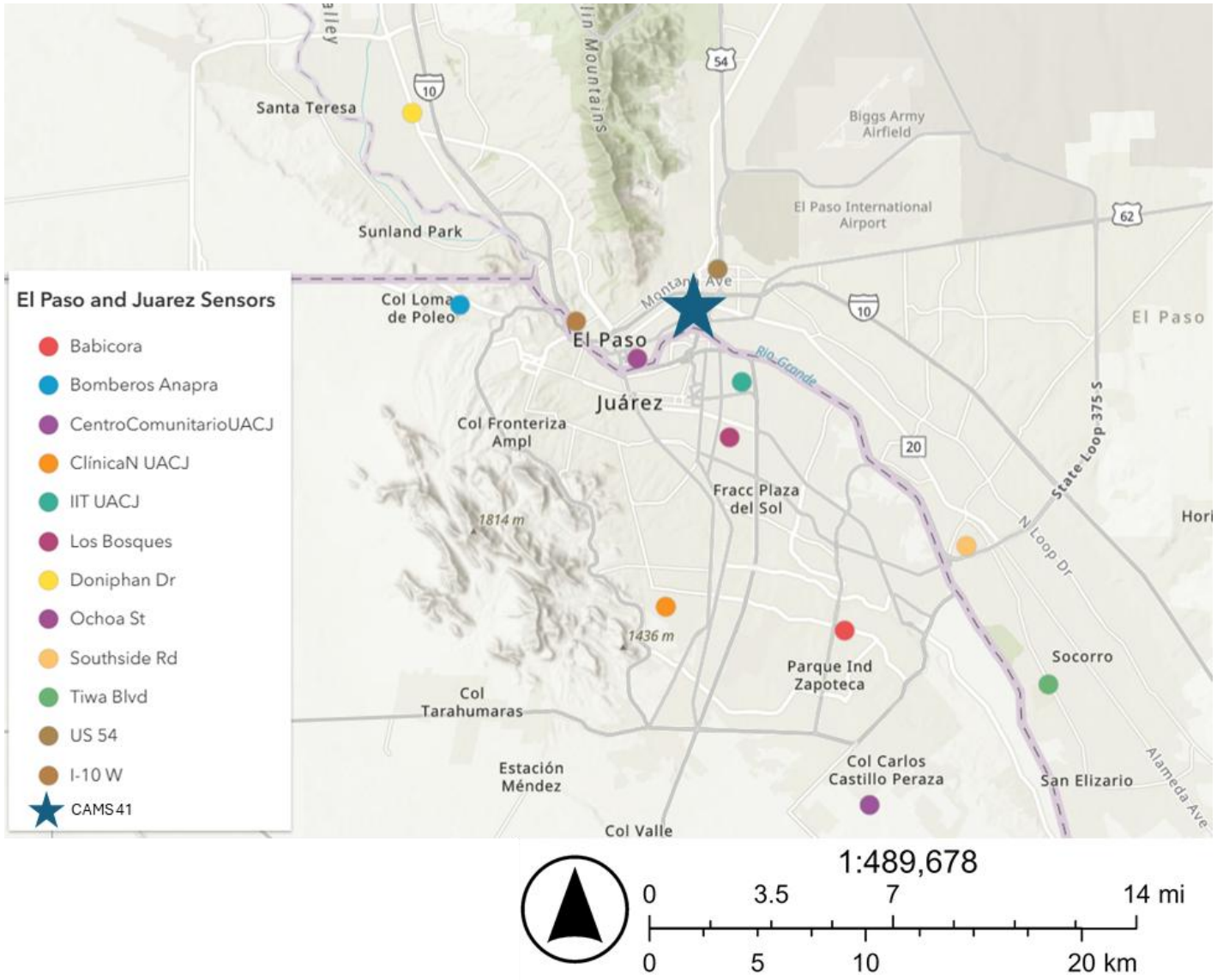
NO_2 Source Category	Key Contributors	Estimated Contribution
On-Road Motor Vehicles	Gasoline cars, diesel trucks & buses (especially in heavy traffic and border queues)	Majority – ~50% or more of NO_x emissions. Primary source of urban NO2
Off-Road Mobile Equipment	Diesel locomotives (freight trains), construction and mining equipment, airport ground engines	Significant (~10–20%). Localized near railyards, construction sites, etc.
Industrial Point Sources	Power plants (gas-fired), oil refinery, large boilers, and generators in the area	Significant (~20–30%). Steady emissions can create plumes (e.g., downwind of a power station).
Other Combustion Sources	Small-scale burning (brick kilns, burning of trash, etc.) and residential fuel use	Minor contributor to NO_2 (<10%). Includes numerous small sources; impact is more local.

Objectives


Expand air monitoring with calibrated low-cost sensors
Improve spatial resolution & binational data sharing
Engage communities & youth awareness

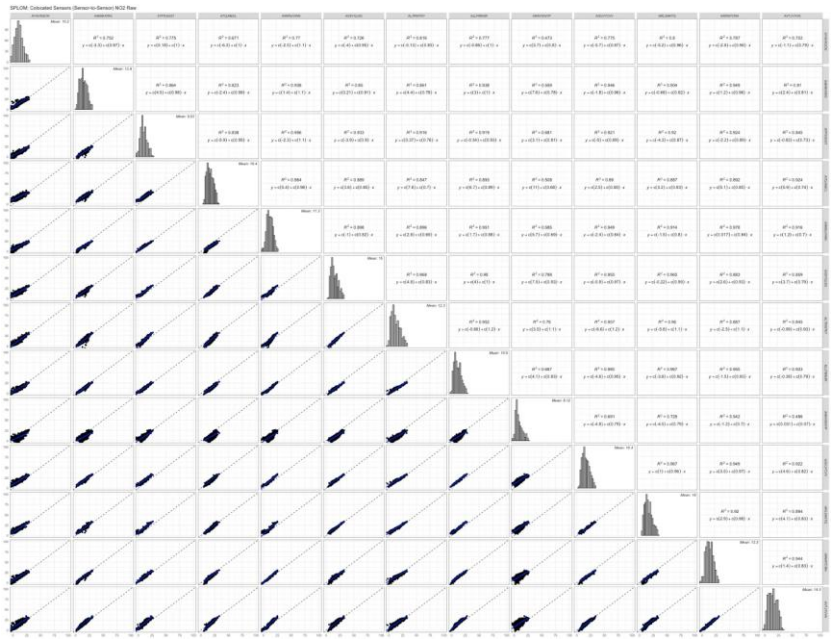
Sensor Network

- 12 Clarity Node-S Sensors deployed
- 6 in El Paso, 6 in Juarez (plus CAMS-41 collocated sensor)
- Covered priority neighborhoods & Traffic Corridors



Methods & Calibration

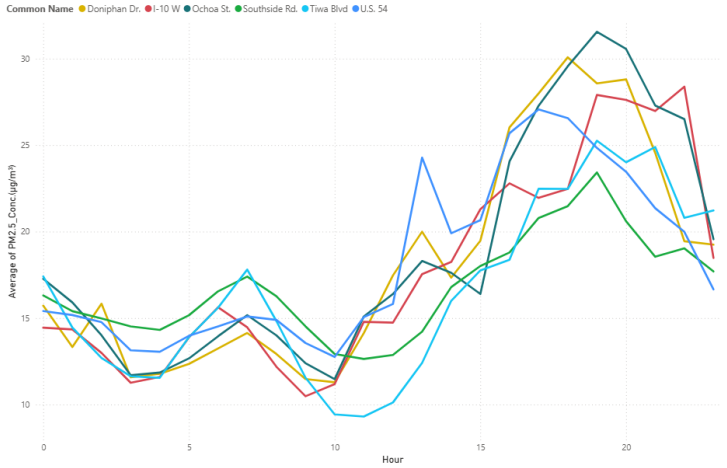
- Data collections every ~3 min
- QA/QC: collocation at CAMS-41, base sensor normalization
- Two-step correction: FEM regression + sensor alignment)



$PM_{2.5}$ Results

- Extreme Spikes > 5,000 µg/m3 during dust events
- Routine averages: 13-20 µg/m3 when capped <100 µg/m3
- El Paso sites (lower peaks) vs Juarez (Higher Spikes), however they're still high considering $PM_{2.5}$ NAAQS
- Extreme episodic events contributed to high PM readings

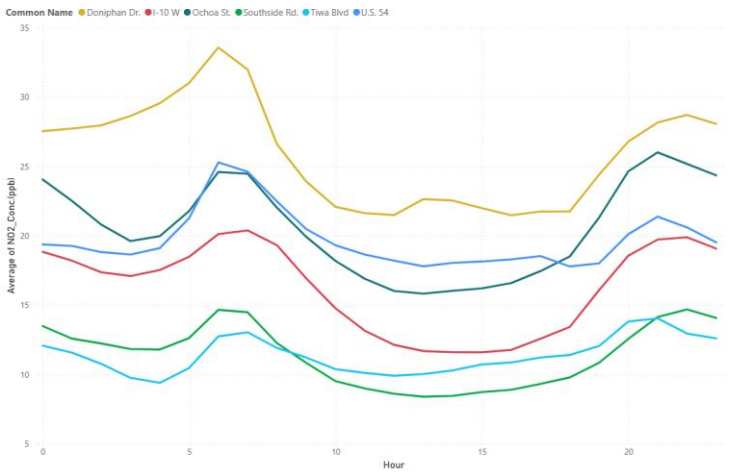
Summary Statistics $PM_{2.5}$ µg/m³ (Uncapped)			
Sensor Name	$PM_{2.5}$ 1hr Max	$PM_{2.5}$ Period Average	$PM_{2.5}$ 24hr Max
Babicora	4752.0	287.6	413.3
Bomberos Anapra	5179.1	479.0	1058.7
Centro Comunitario UACJ	3174.7	179.0	318.8
Clínica Nutricional UACJ	3498.1	82.5	213.9
Doniphan Dr.	2762.9	25.2	71.2
I-10 W	2701.6	117.0	95.4
IIT UACJ	3580.6	1232.8	230.6
Los Bosques	2188.8	188.5	1741.1
Ochoa St.	900.6	21.1	248.9
Southside Rd.	281.8	16.8	76.2
Tiwa Blvd	382.2	16.5	41.0
U.S. 54	615.1	18.6	52.7

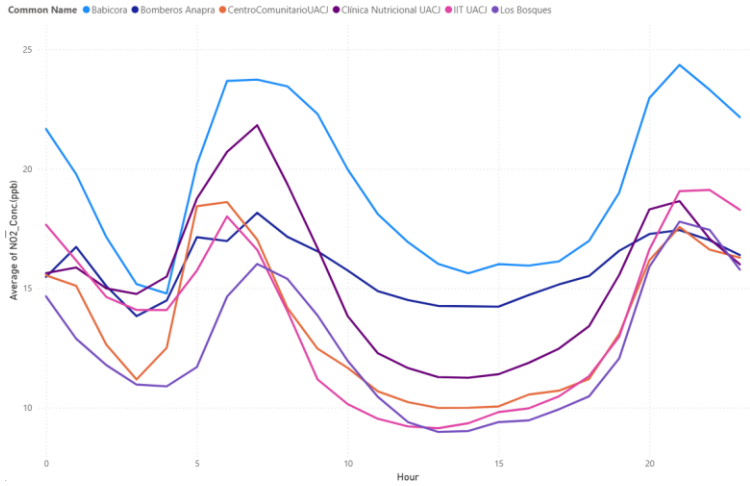


NO_2 Results

- Max 1-hour: 70 ppb (Doniphan) & 65 ppb (US-54)
- Averages: 11-25 ppb across sites
- Strong link to traffic corridors; less variability in Juarez

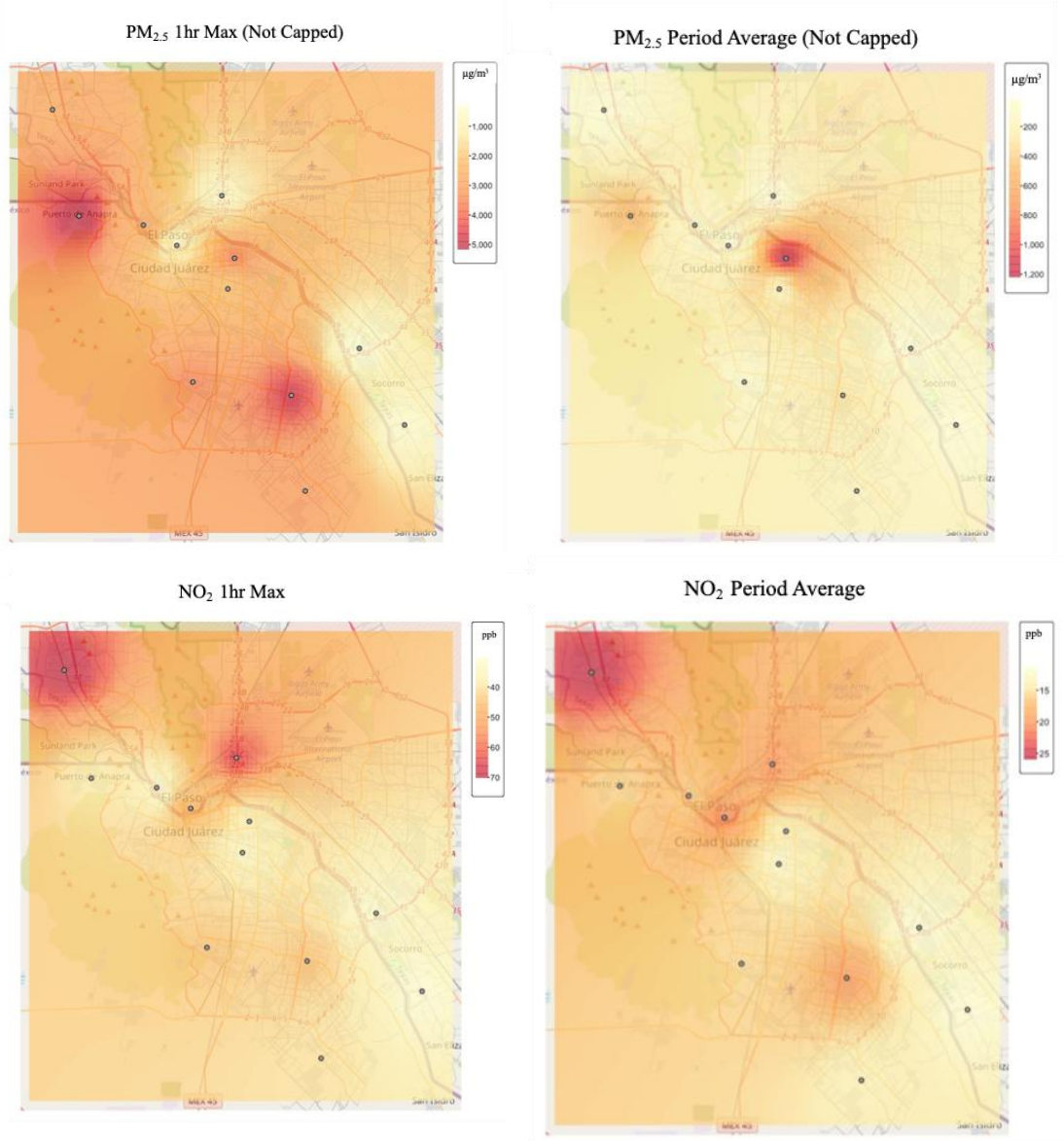
Summary Statistics (NO_2 ppb)			
Sensor Name	NO_2 1hr Max	NO_2 Period Average	NO_2 24hr Max
Babicora	44.6	19.5	31.0
Bomberos Anapra	38.2	15.8	24.5
Centro Comunitario UACJ	39.9	13.5	24.2
Clínica Nutricional UACJ	44.5	15.5	25.9
Doniphan Dr.	70.1	25.9	16.3
I-10 W	33.7	16.4	39.2
IIT UACJ	36.9	13.9	26.5
Los Bosques	35.0	12.7	24.5
Ochoa St.	46.9	20.7	22.7
Southside Rd.	31.6	11.5	32.5
Tiwa Blvd	30.3	11.4	20.0
U.S. 54	64.9	19.7	18.8





Spatial Patterns

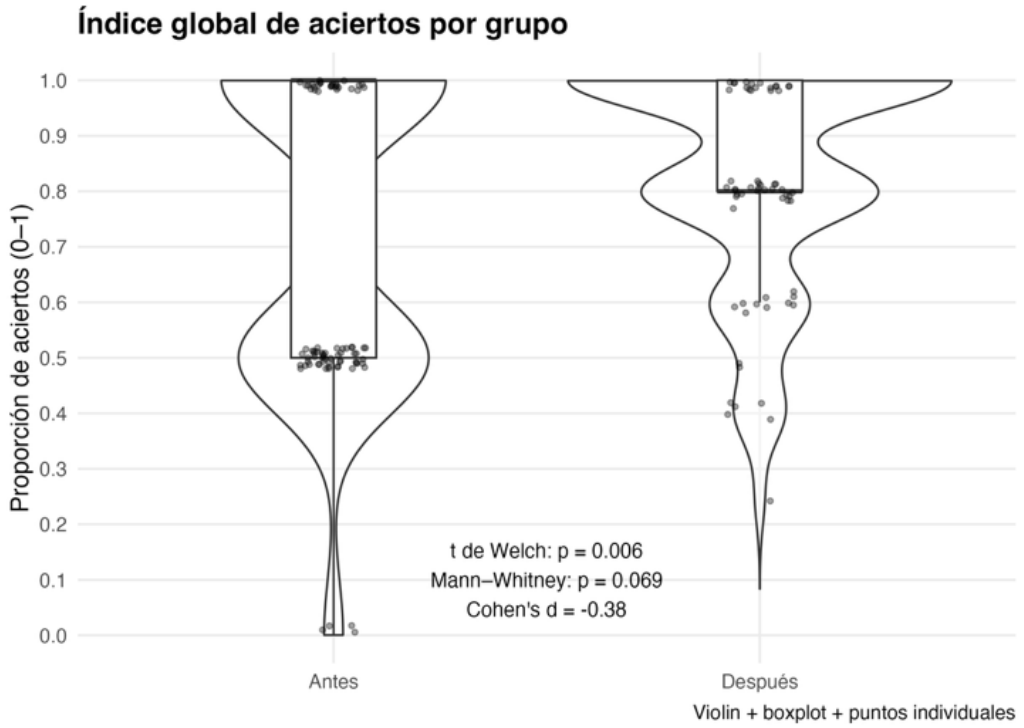
- $PM_{2.5}$ hotspots: Anapra, Babicora, IIT Juarez
- Norder traffic corridors show persistent NO_2 gradients
- Dust storms dominate regional $PM_{2.5}$ loads



Outreach

- Air Detectives workshop with 114 students
- Hands-on stations: AQI flags, dust experiments, lung health
- Significant pre/post knowledge improvement

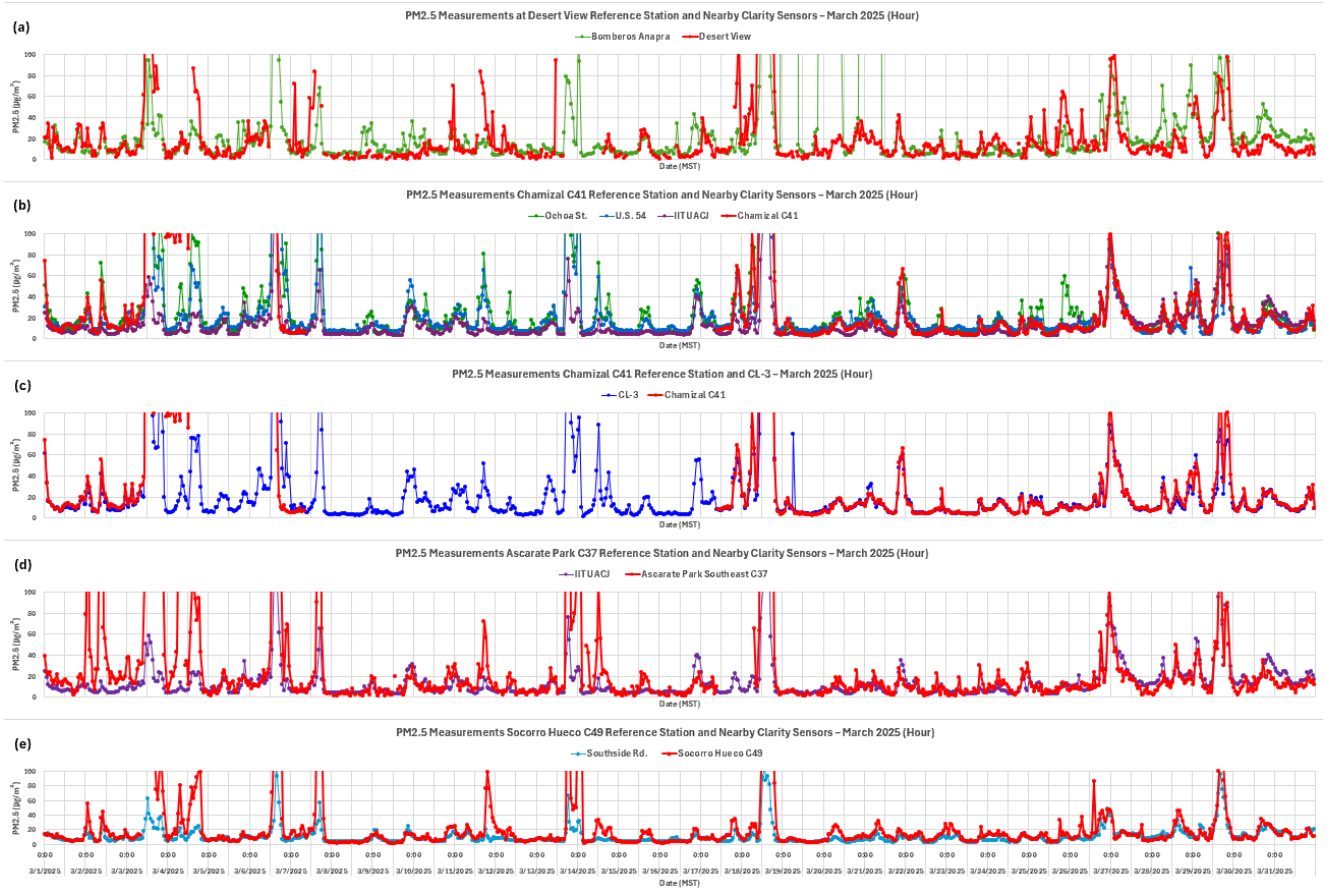
Topic	Before (%)	After (%)	Change
What is air pollution?	93.0	92.8	≈
Major/mobile pollution source	71.1	68.7	≈
AQI interpretation (colors)	98.2	81.9	↓
Response to red-level AQI	80.7	92.8	↑
Actions to improve air quality	53.5	94.0	↑↑↑

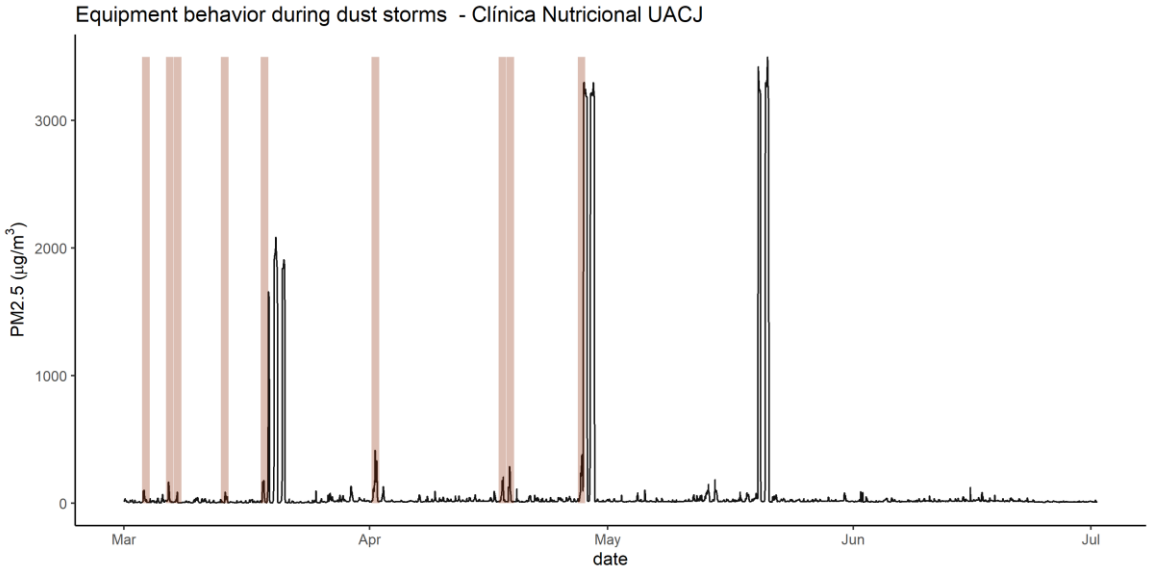


Visual Evidence

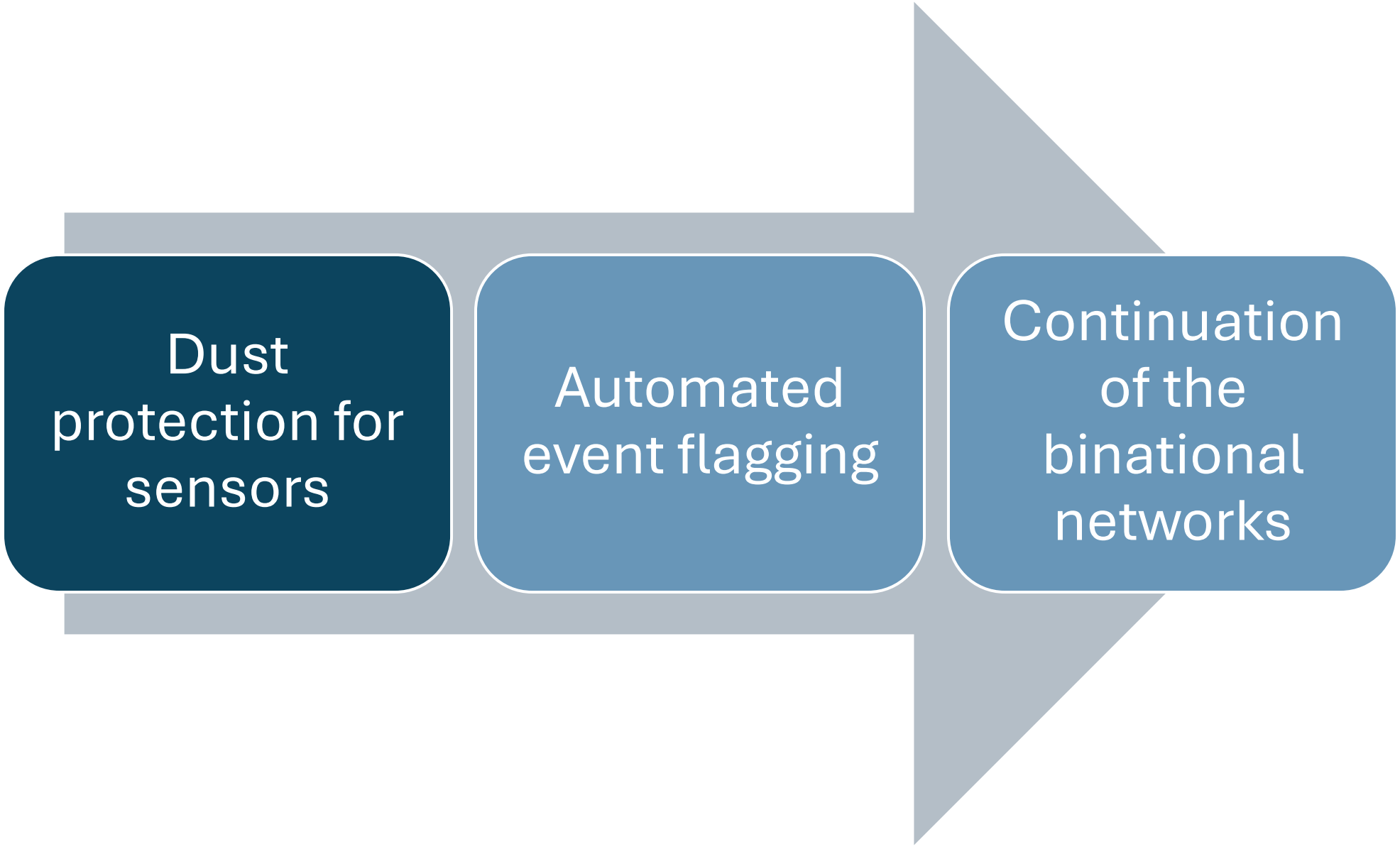
Key Findings

- Dust storms and traffic are causes of high spikes
- Device mounting differences (rooftops vs breathing height siting)

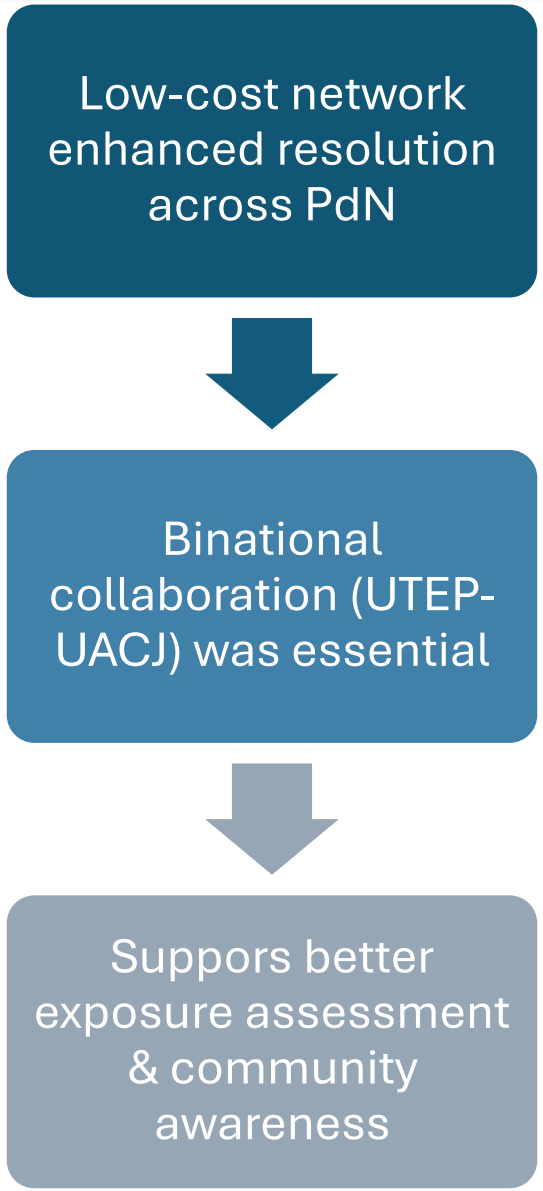




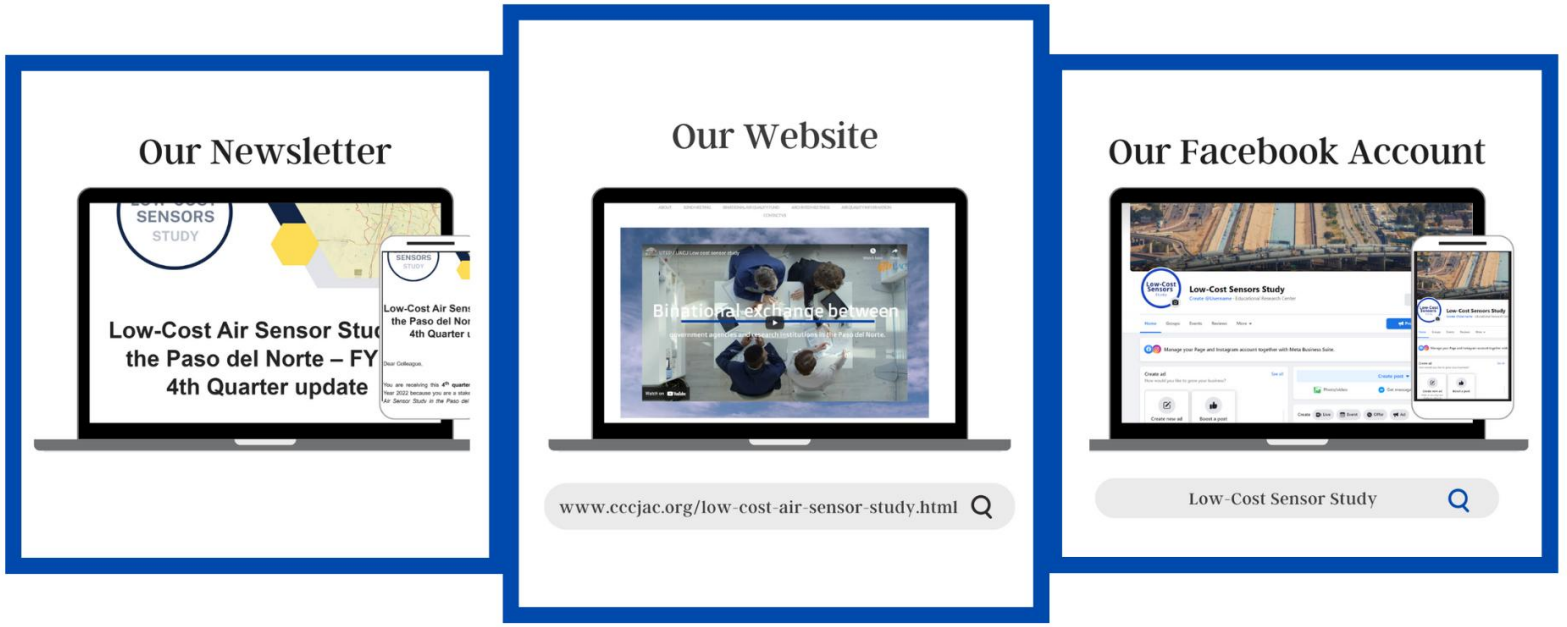
Future Work


Dust protection for sensors
Automated event flagging
Continuation of the binational networks

Conclusion


Low-cost network enhanced resolution across PdN
Binational collaboration (UTEP-UACJ) was essential
Suppors better exposure assessment & community awareness

Communications



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