Ultrafine Particles Downwind of Los Angeles International Airport: Implications for Exposure Assessment

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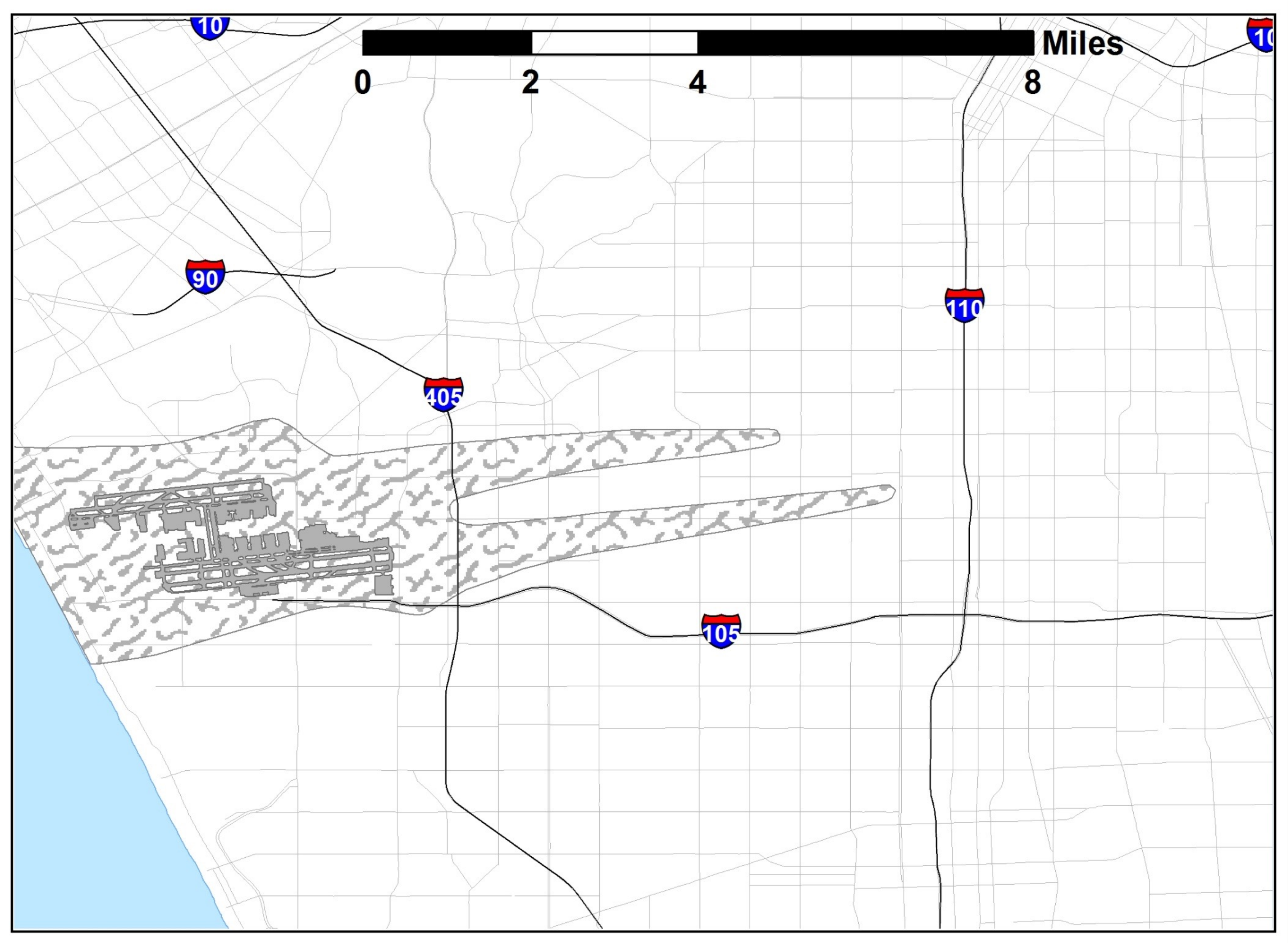
AIRPORTS: AN **UNDERESTIMATED LOCAL SOURCE** OF ULTRAFINE PARTICLES

- Aviation emissions impact local, regional and global air quality.
- **Until recently, the focus was on few hundred meters or several kilometers from the airport complex.**
    - *Dodson et al. 20094* (Warwick, RI): aviation emissions contributed 24–28% of the total black carbon (BC) measured at five sites 0.16– 3.7 km from the airport.
    - *Fanning et al. 2007* (LAX): measured particle numbers concentrations in the 10– 100 nm range and found significant increases above background at 1.9, 2.7, and 3.3 km
    - Several other studies estimated contribution to NOx (*Carslaw et al. 2006*) and SO2 (*Yu et al. 2004*) emissions.

AIRPORTS: AN **UNDERESTIMATED LOCAL SOURCE** OF ULTRAFINE PARTICLES

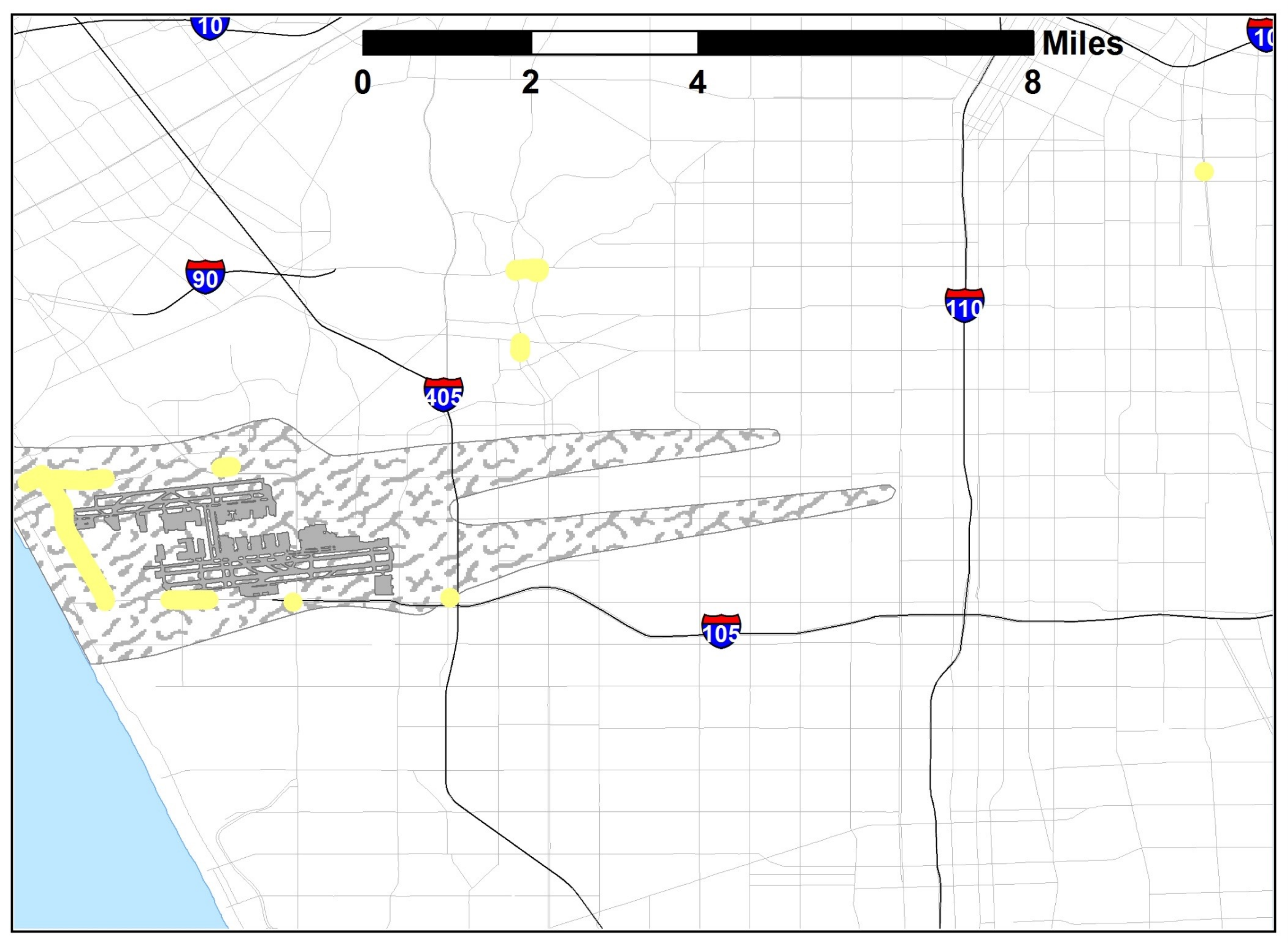
- Two **recent studies have refined our understanding of aviation emission impacts on local air quality**, particularly, in the context of particle number concentrations.
  - Hudda et al. 2014, *Env. Sc. & Tech*
  - Keuken et al. 2015, *Atmos Environ*.

LAX: Los Angeles International Airport



SPATIAL PATTERN

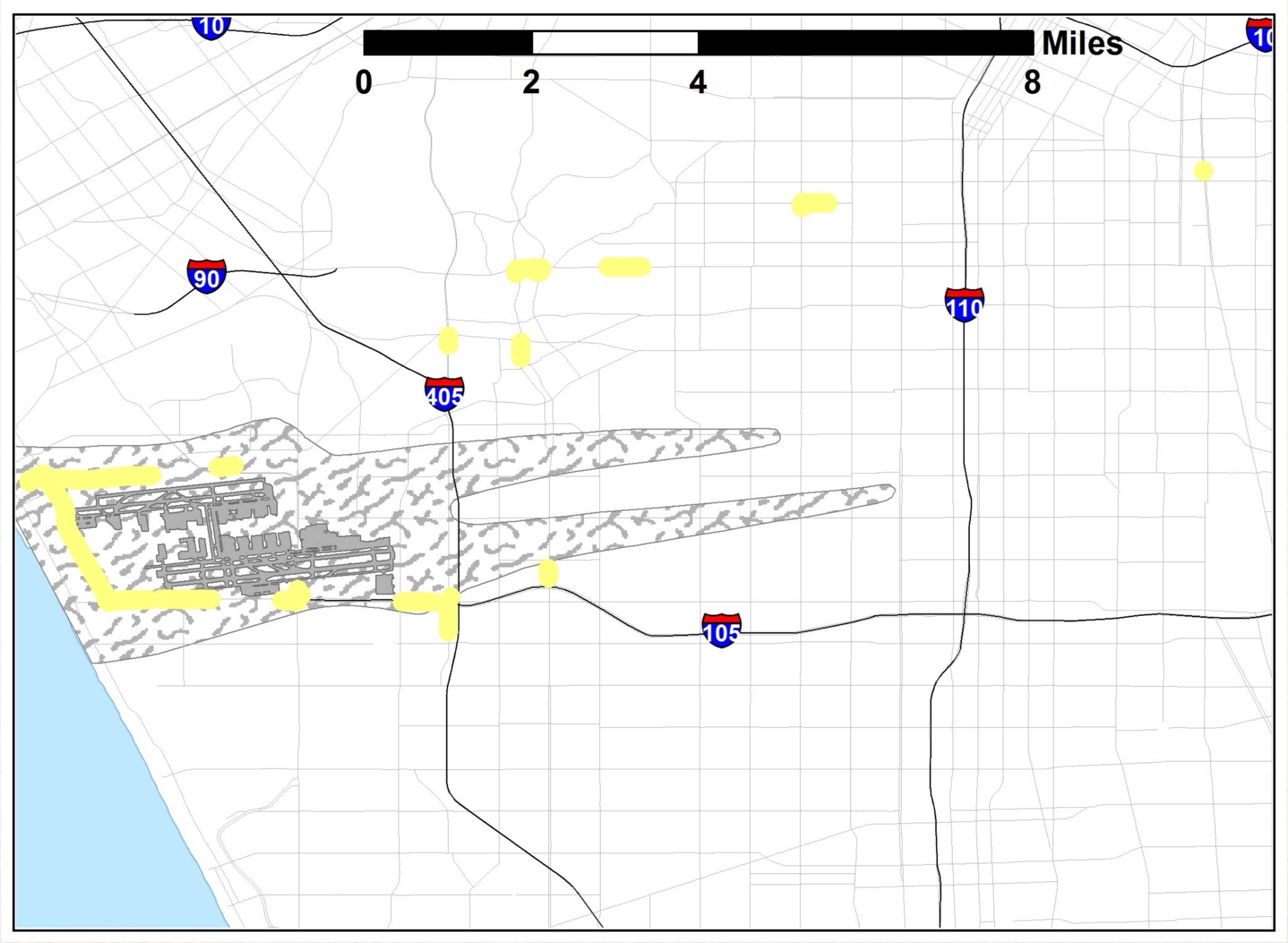
Mobile monitoring of particle number concentrations



5th Percentile

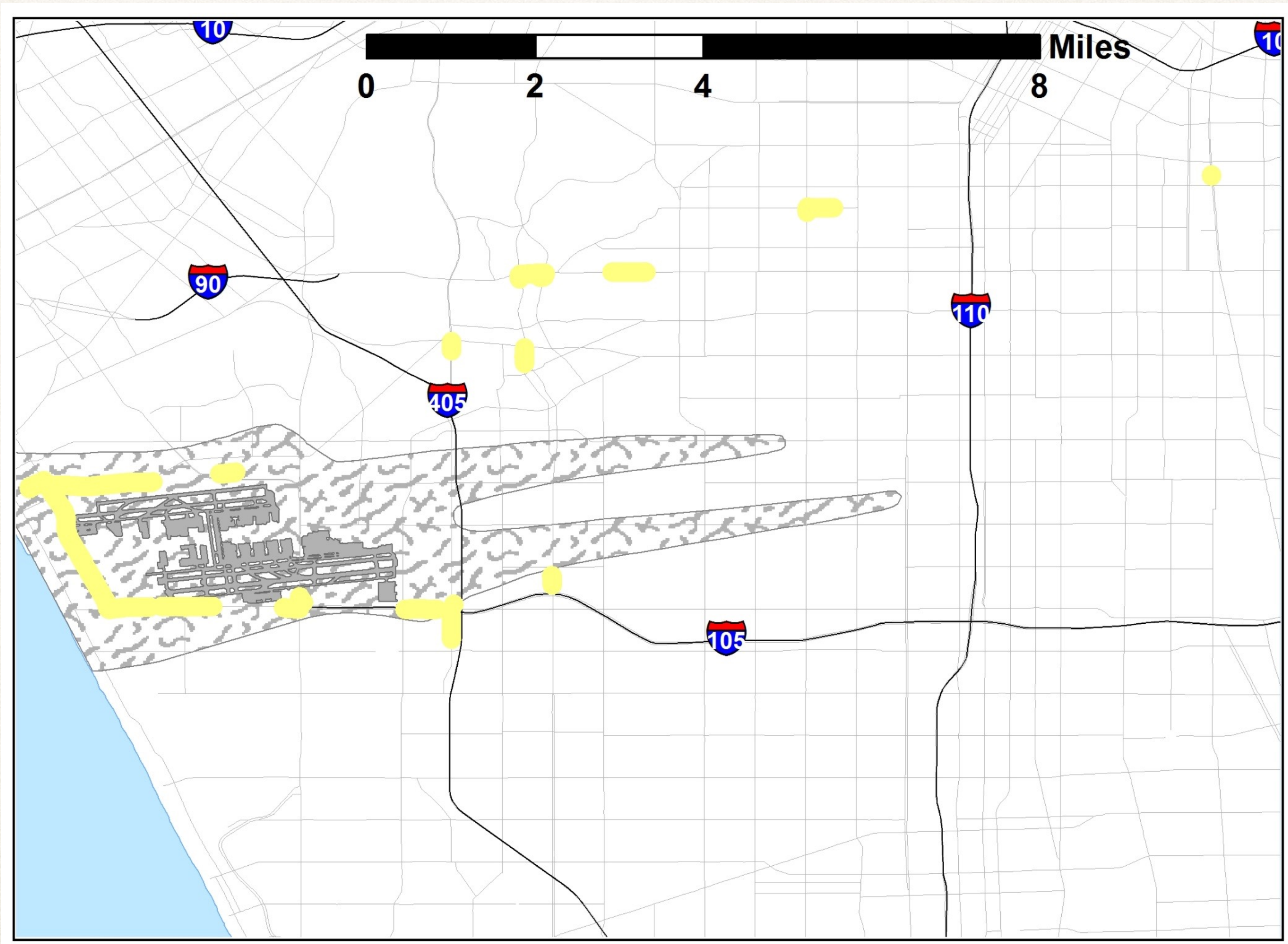
SPATIAL PATTERN

Mobile monitoring of particle number concentrations



10th Percentile

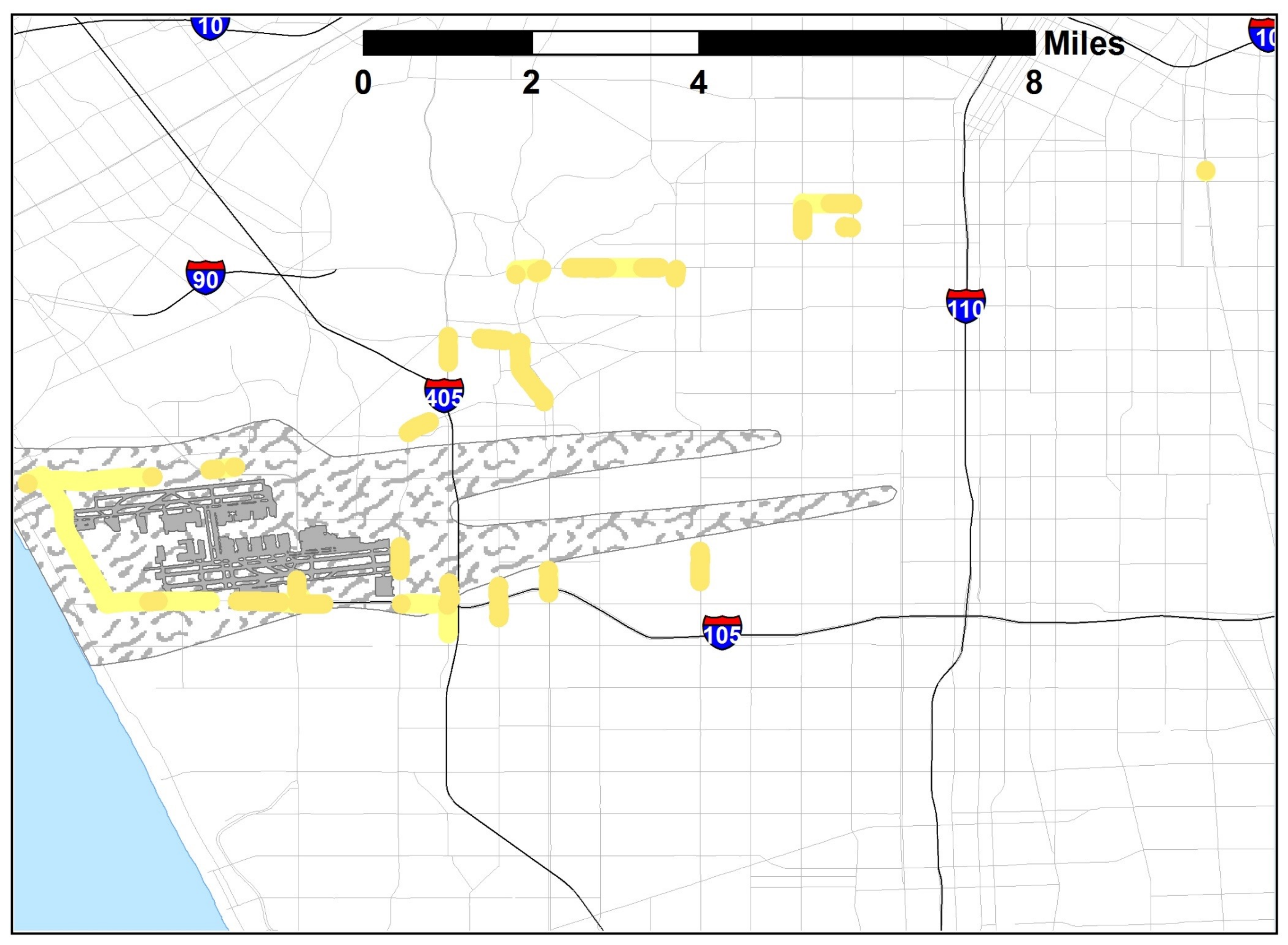
SPATIAL PATTERN
Mobile monitoring of particle number concentrations



15th Percentile

SPATIAL PATTERN

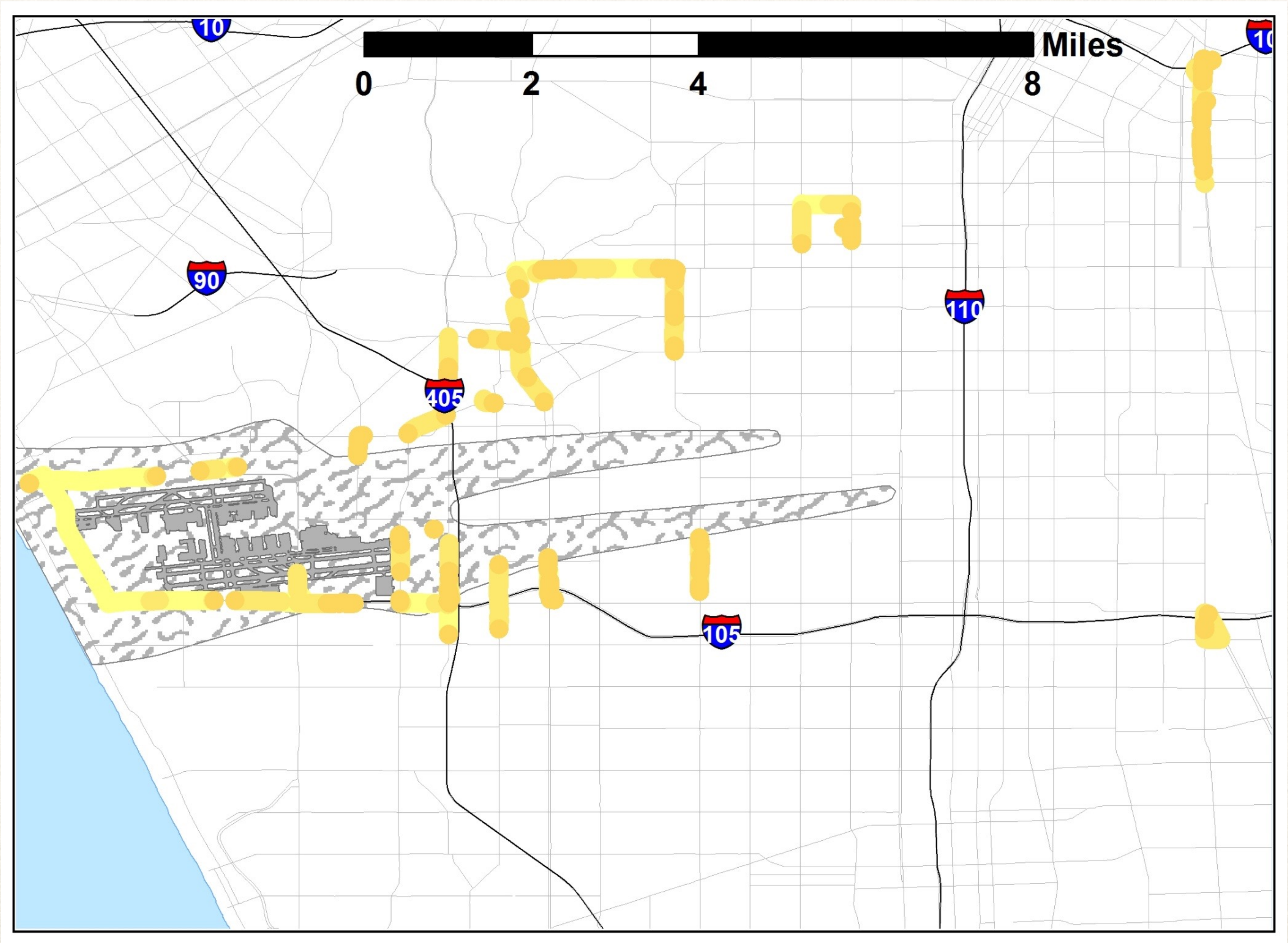
Mobile monitoring of particle number concentrations



20th Percentile

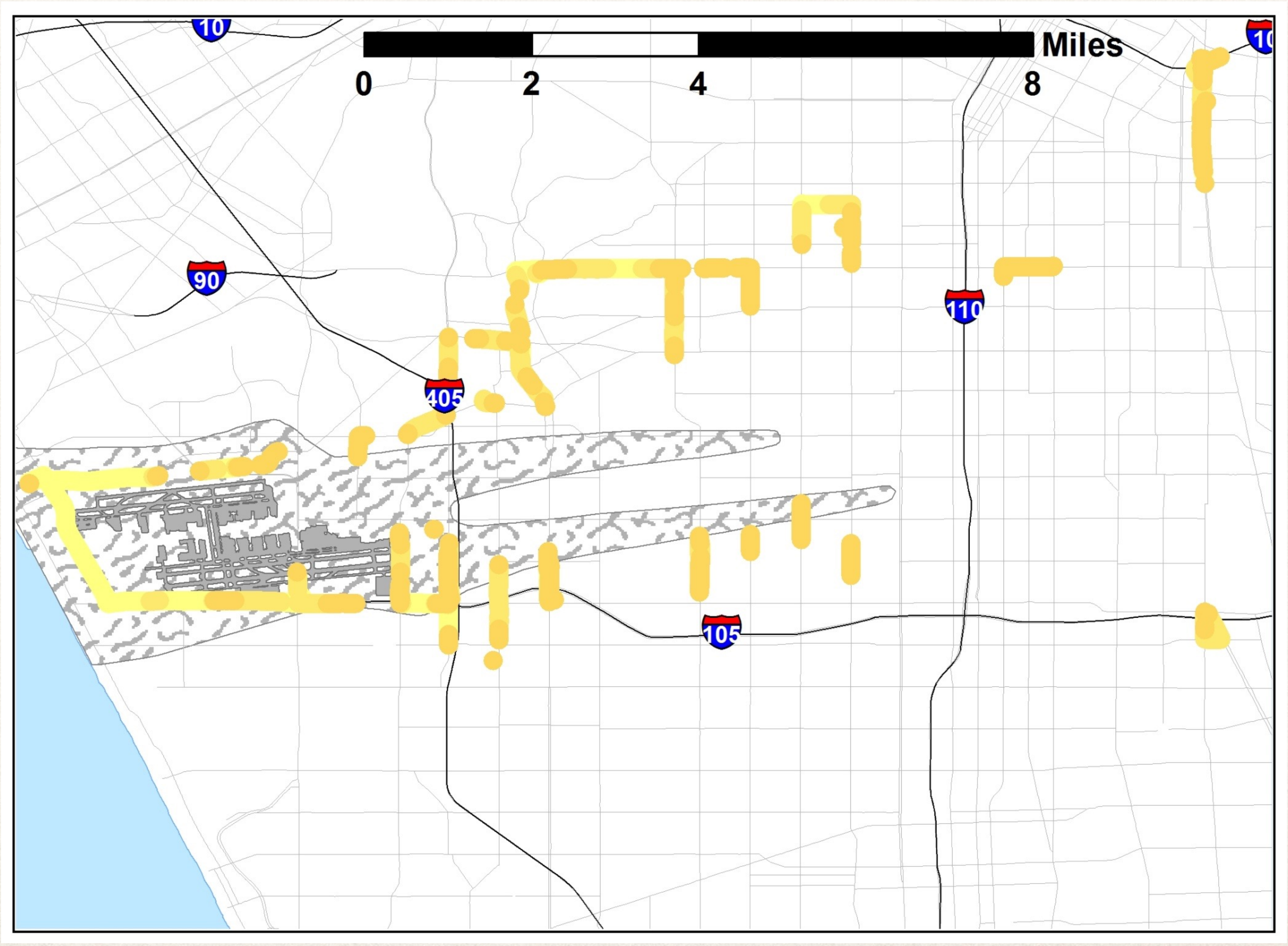
SPATIAL PATTERN

Mobile monitoring of particle number concentrations



25th Percentile

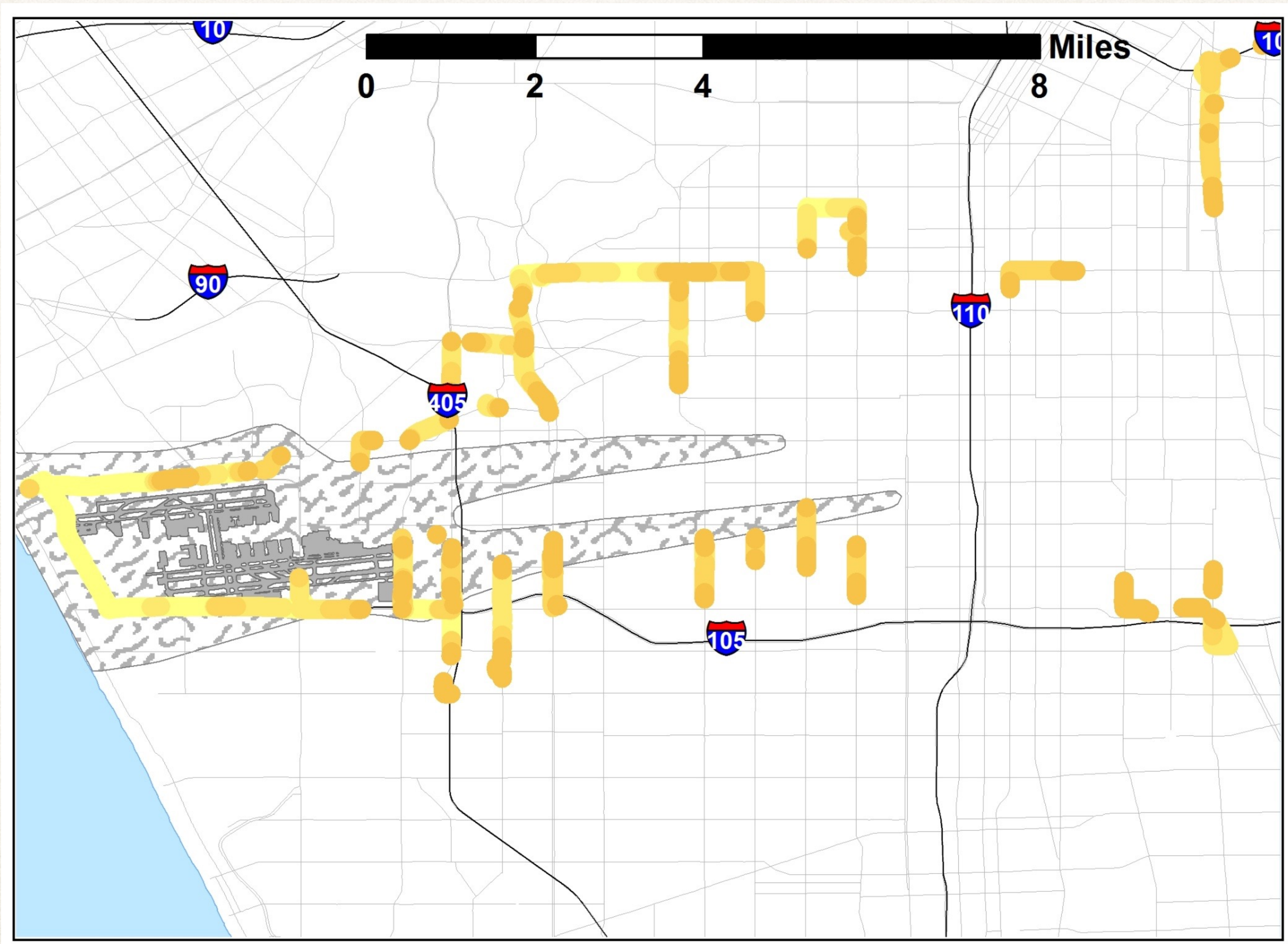
SPATIAL PATTERN
Mobile monitoring of particle number concentrations



30th Percentile

SPATIAL PATTERN

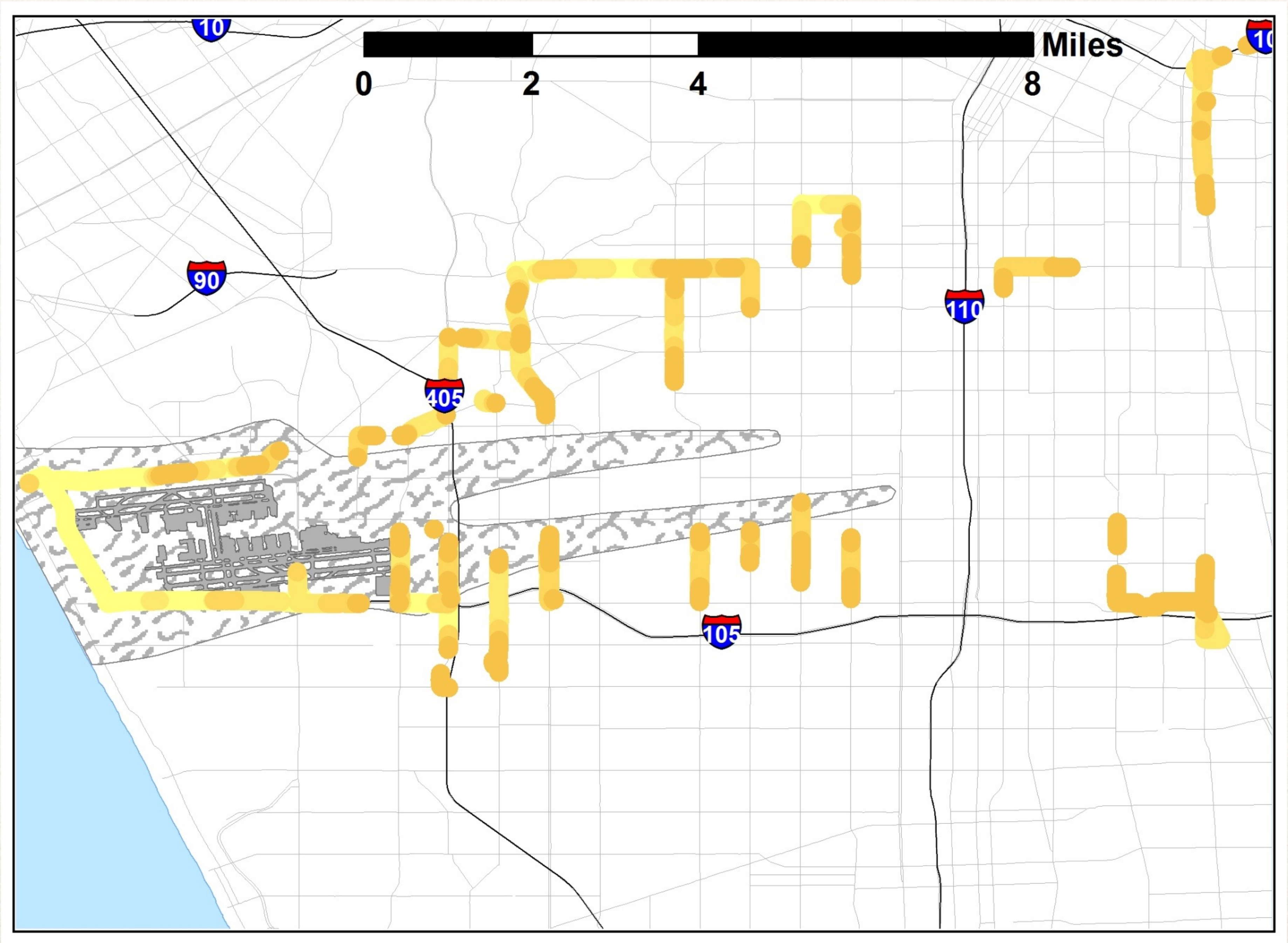
Mobile monitoring of particle number concentrations



35th Percentile

SPATIAL PATTERN

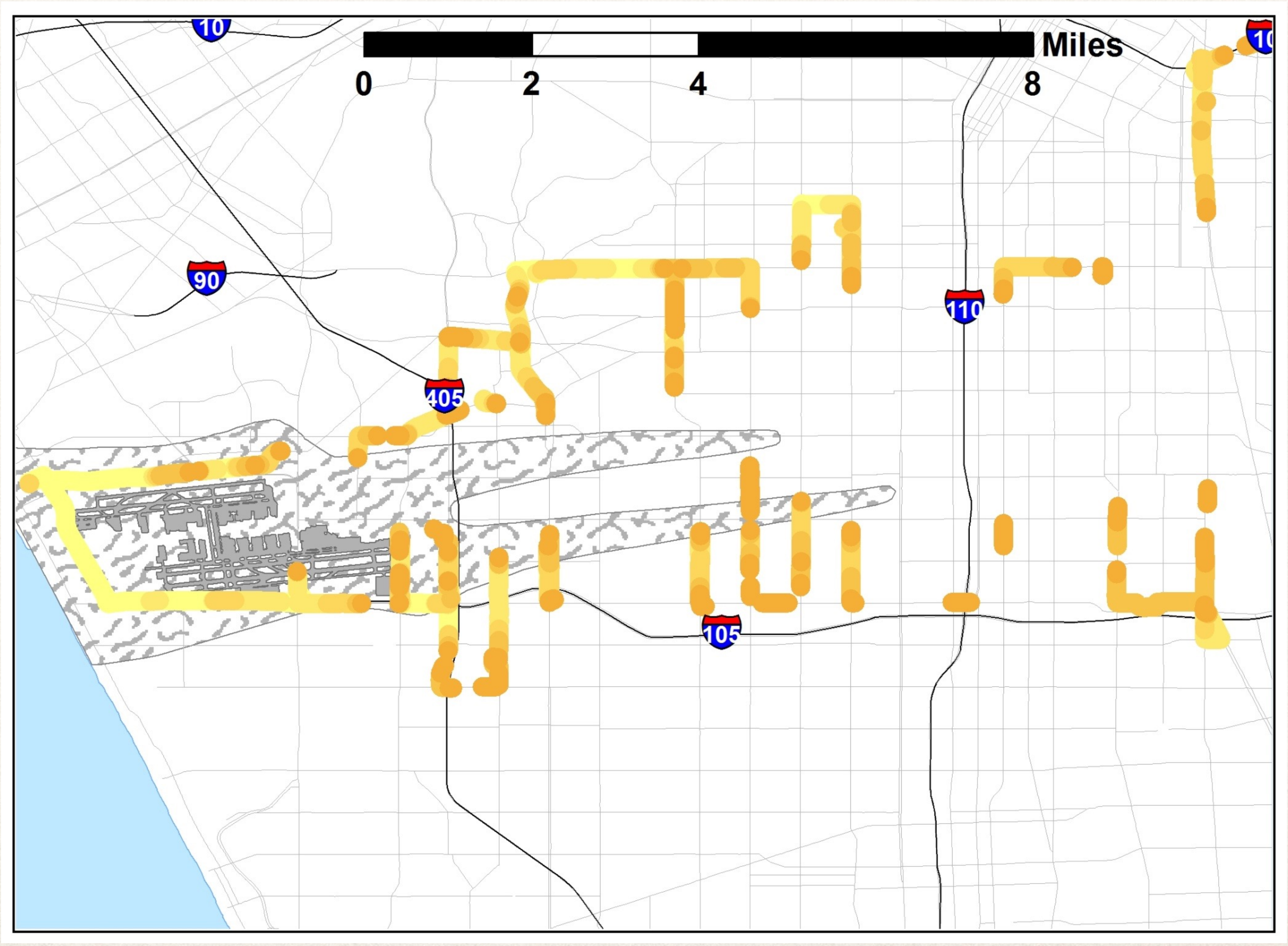
Mobile monitoring of particle number concentrations



40th Percentile

SPATIAL PATTERN

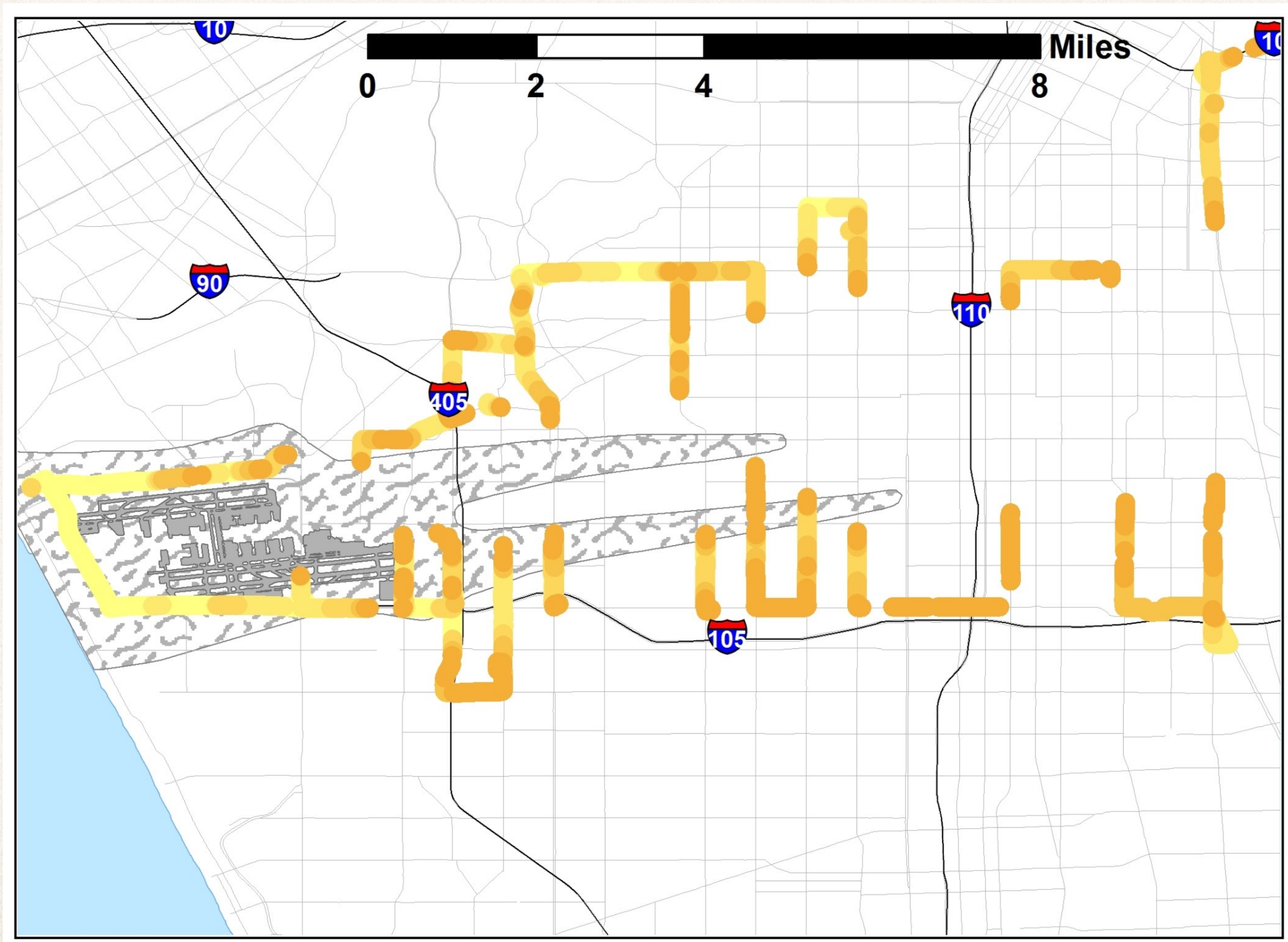
Mobile monitoring of particle number concentrations



45th Percentile

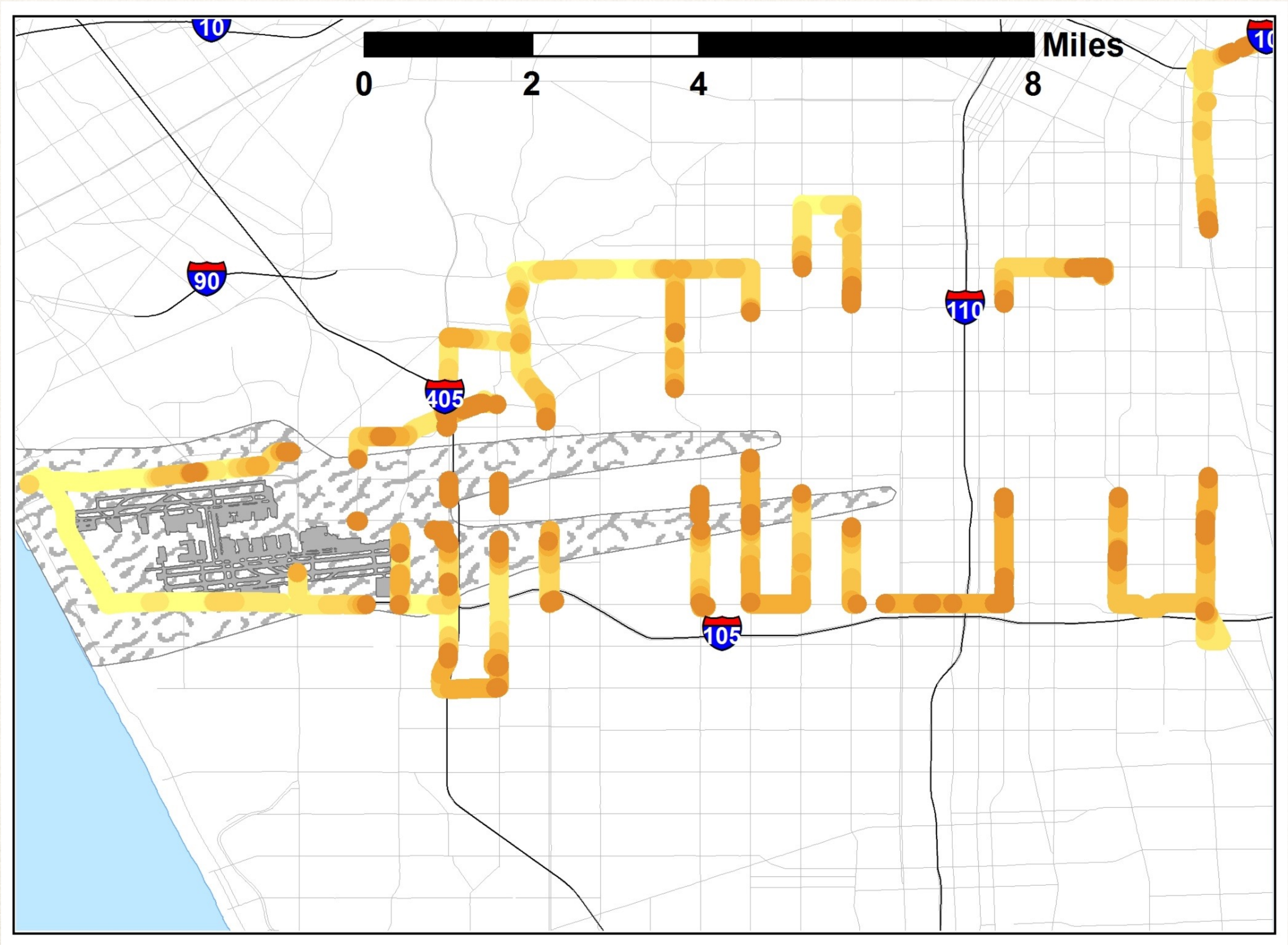
SPATIAL PATTERN

Mobile monitoring of particle number concentrations



50th Percentile

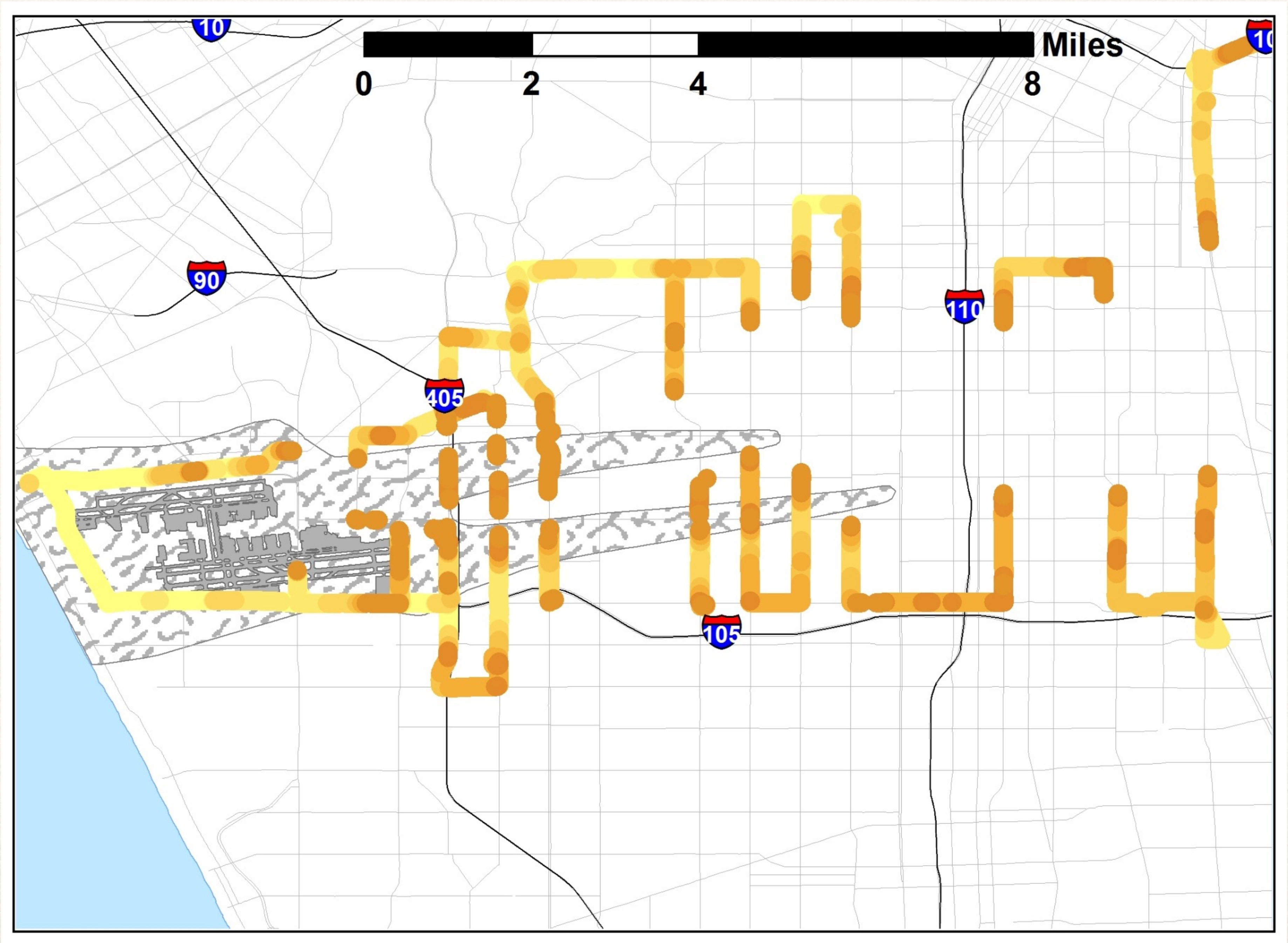
SPATIAL PATTERN
Mobile monitoring of particle number concentrations



55th Percentile

SPATIAL PATTERN

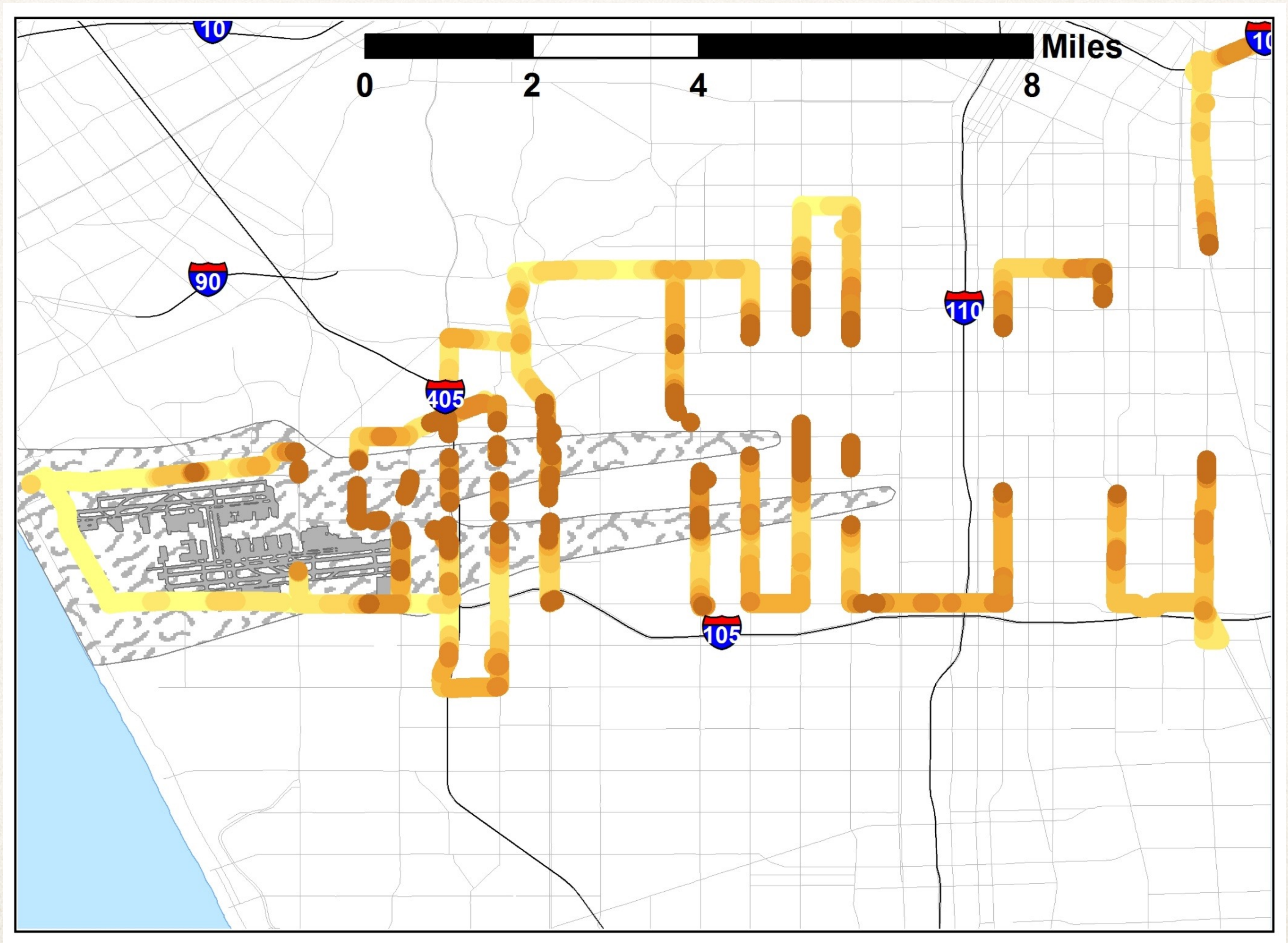
Mobile monitoring of particle number concentrations



60th Percentile

SPATIAL PATTERN

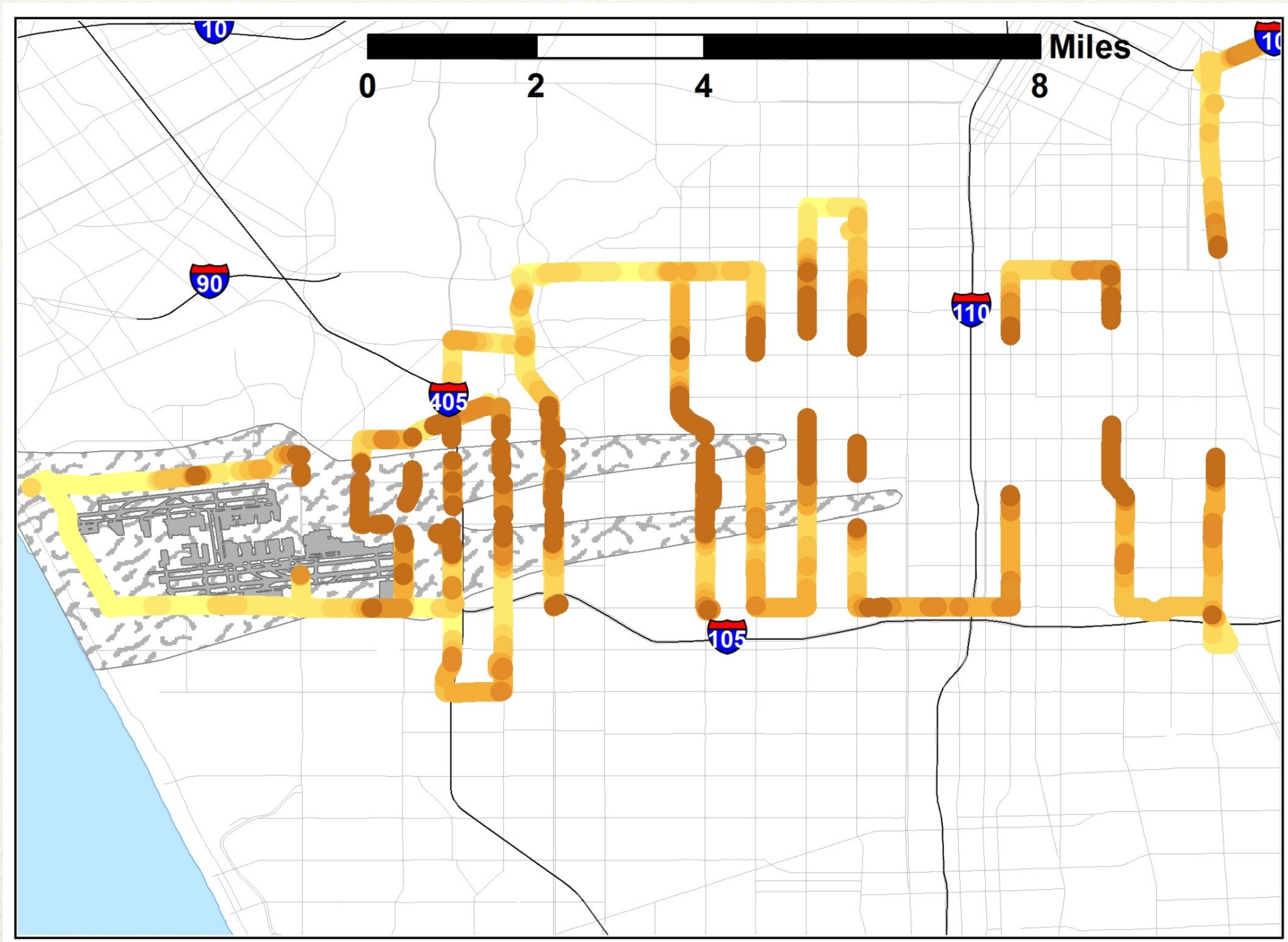
Mobile monitoring of particle number concentrations



65th Percentile

SPATIAL PATTERN

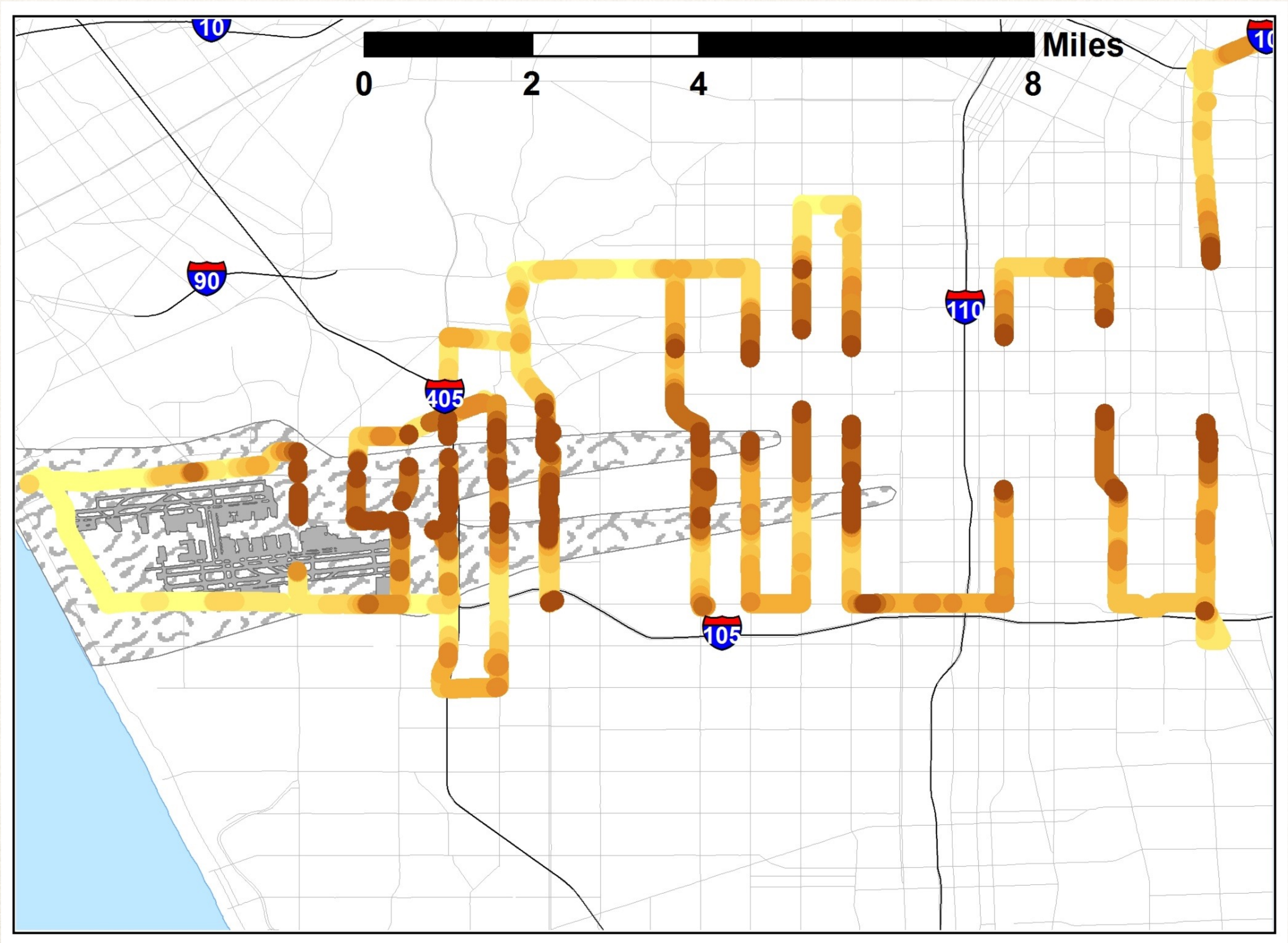
Mobile monitoring of particle number concentrations



70th Percentile

SPATIAL PATTERN

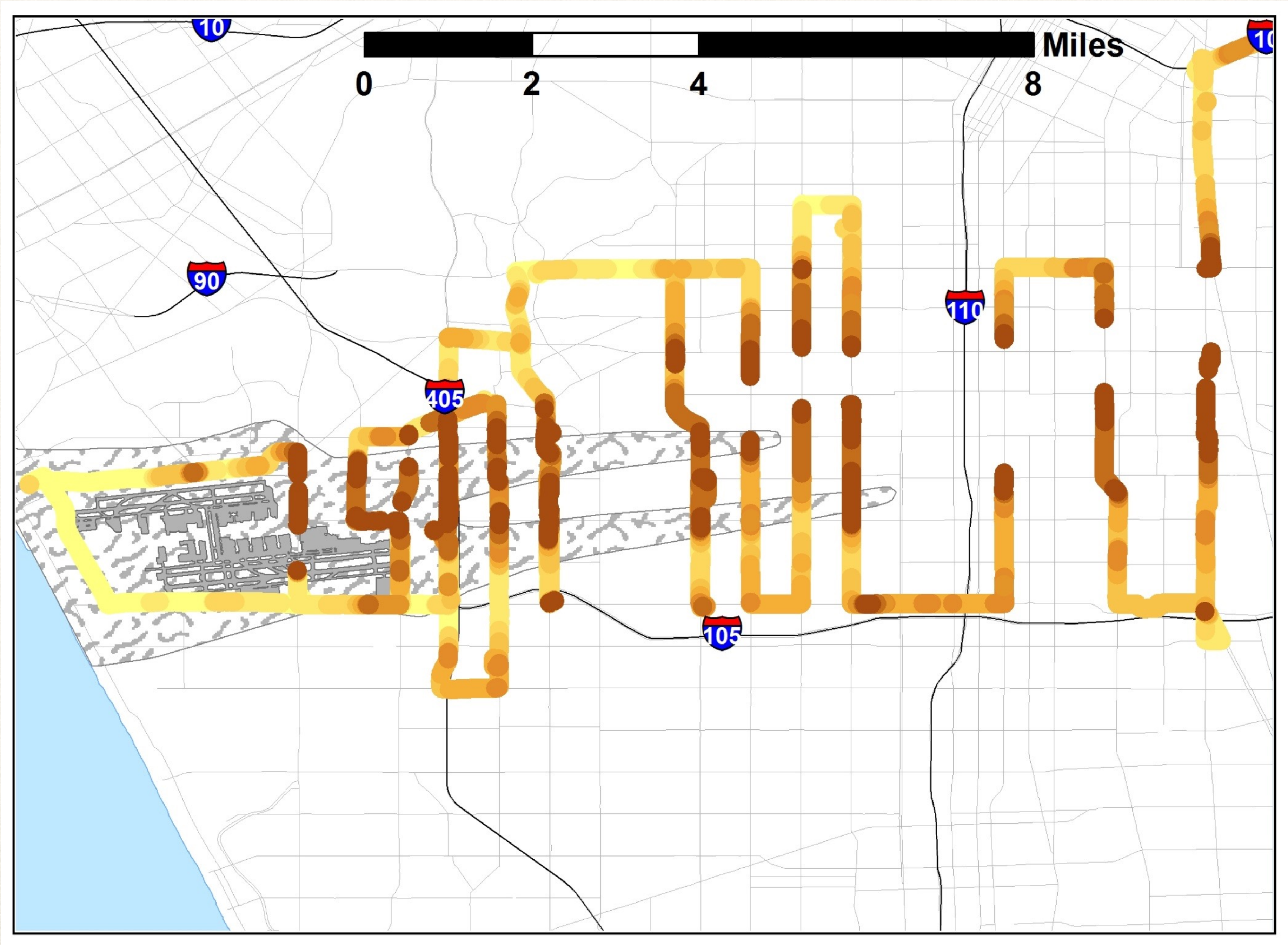
Mobile monitoring of particle number concentrations



75th Percentile

SPATIAL PATTERN

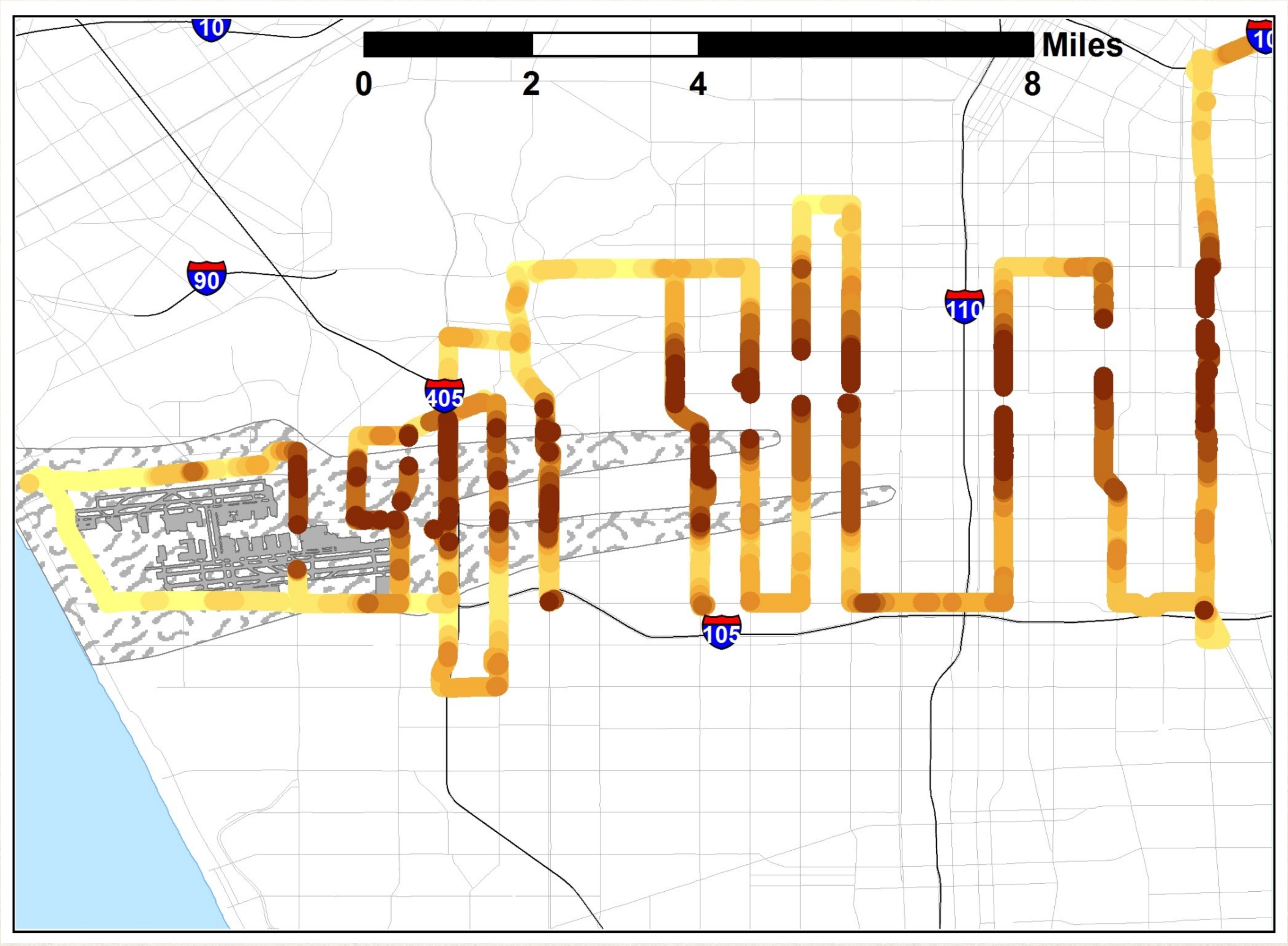
Mobile monitoring of particle number concentrations



80th Percentile

SPATIAL PATTERN

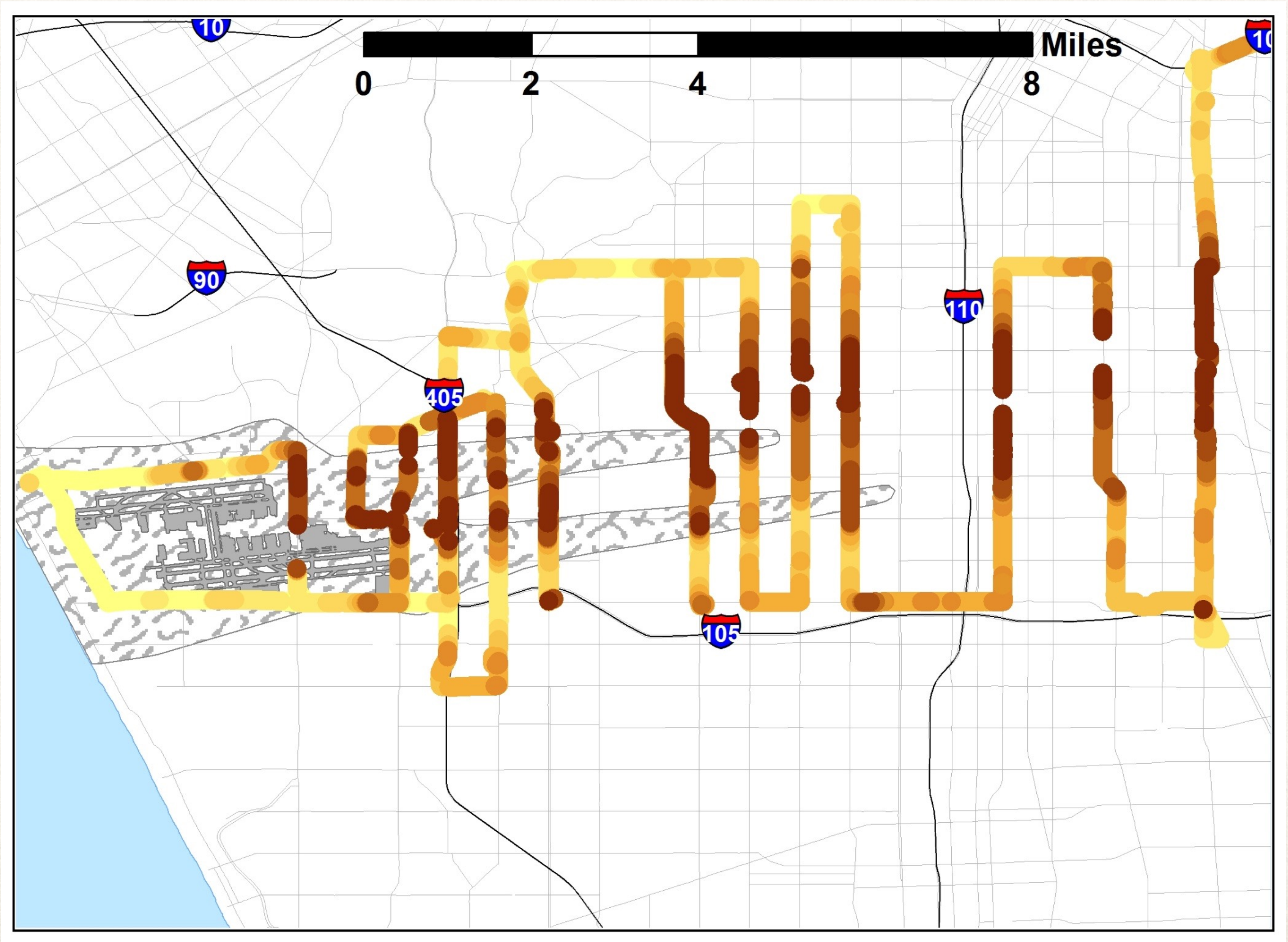
Mobile monitoring of particle number concentrations



85th Percentile

SPATIAL PATTERN

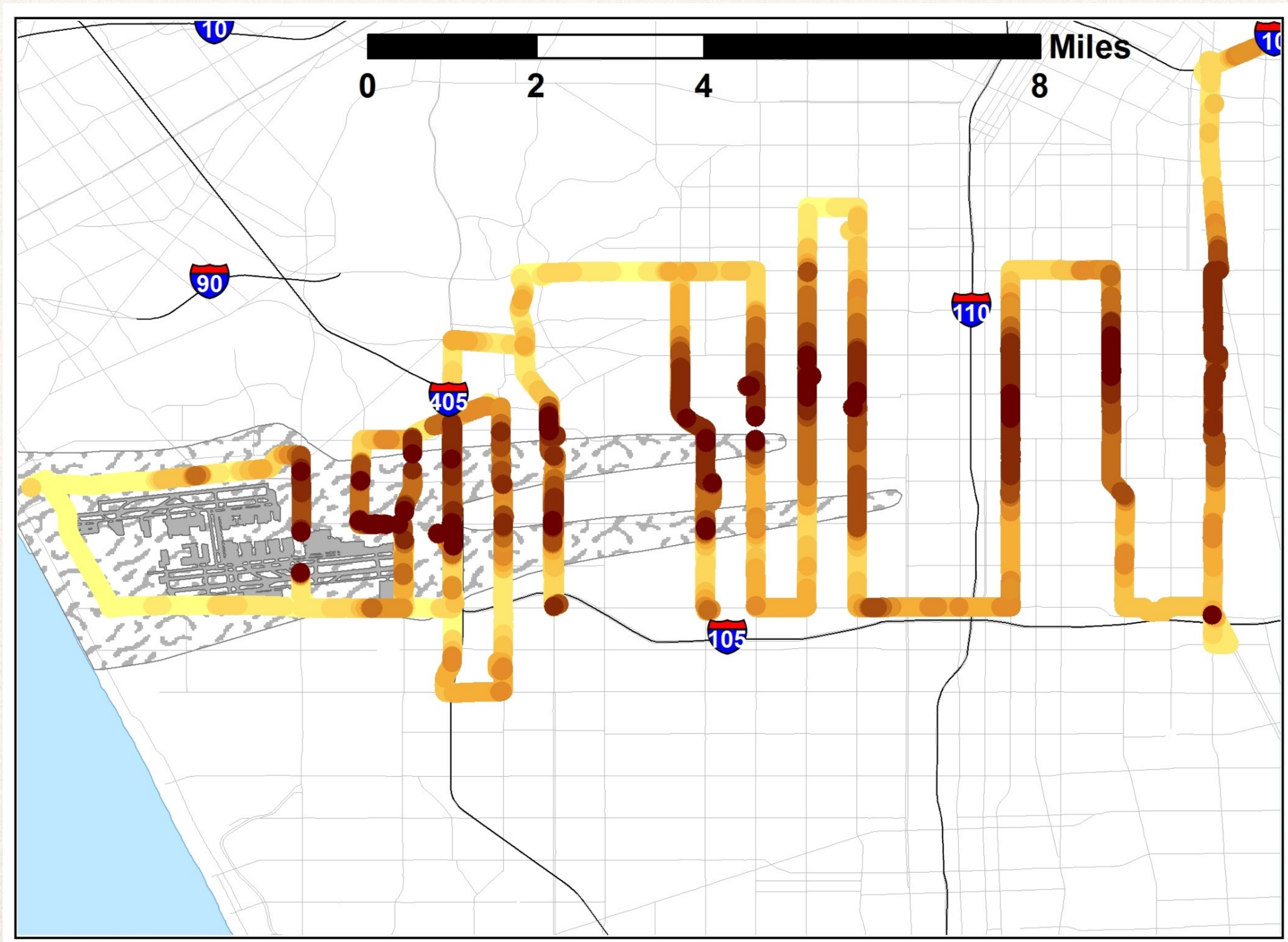
Mobile monitoring of particle number concentrations



90th Percentile

SPATIAL PATTERN

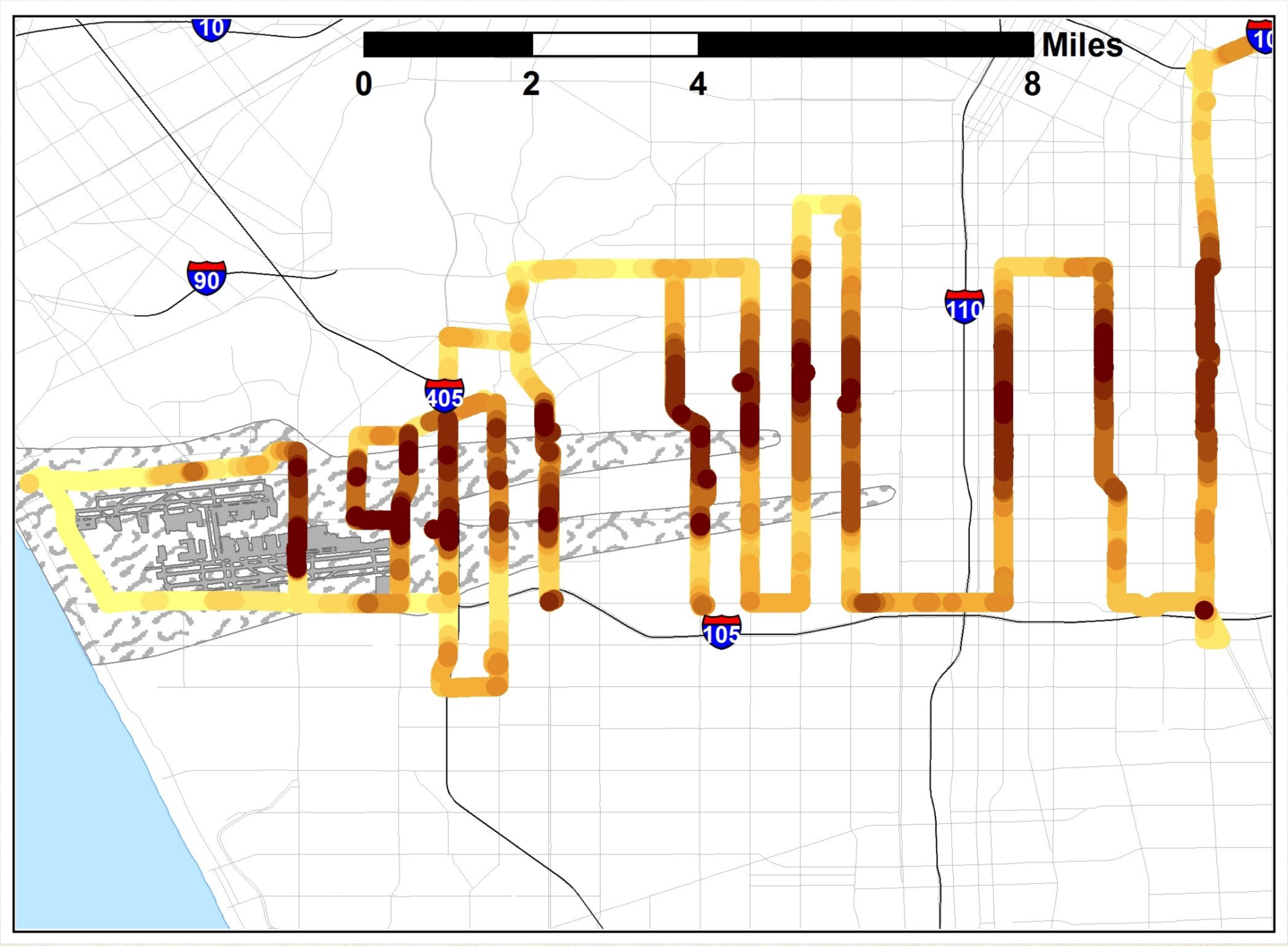
Mobile monitoring of particle number concentrations



95th Percentile

SPATIAL PATTERN

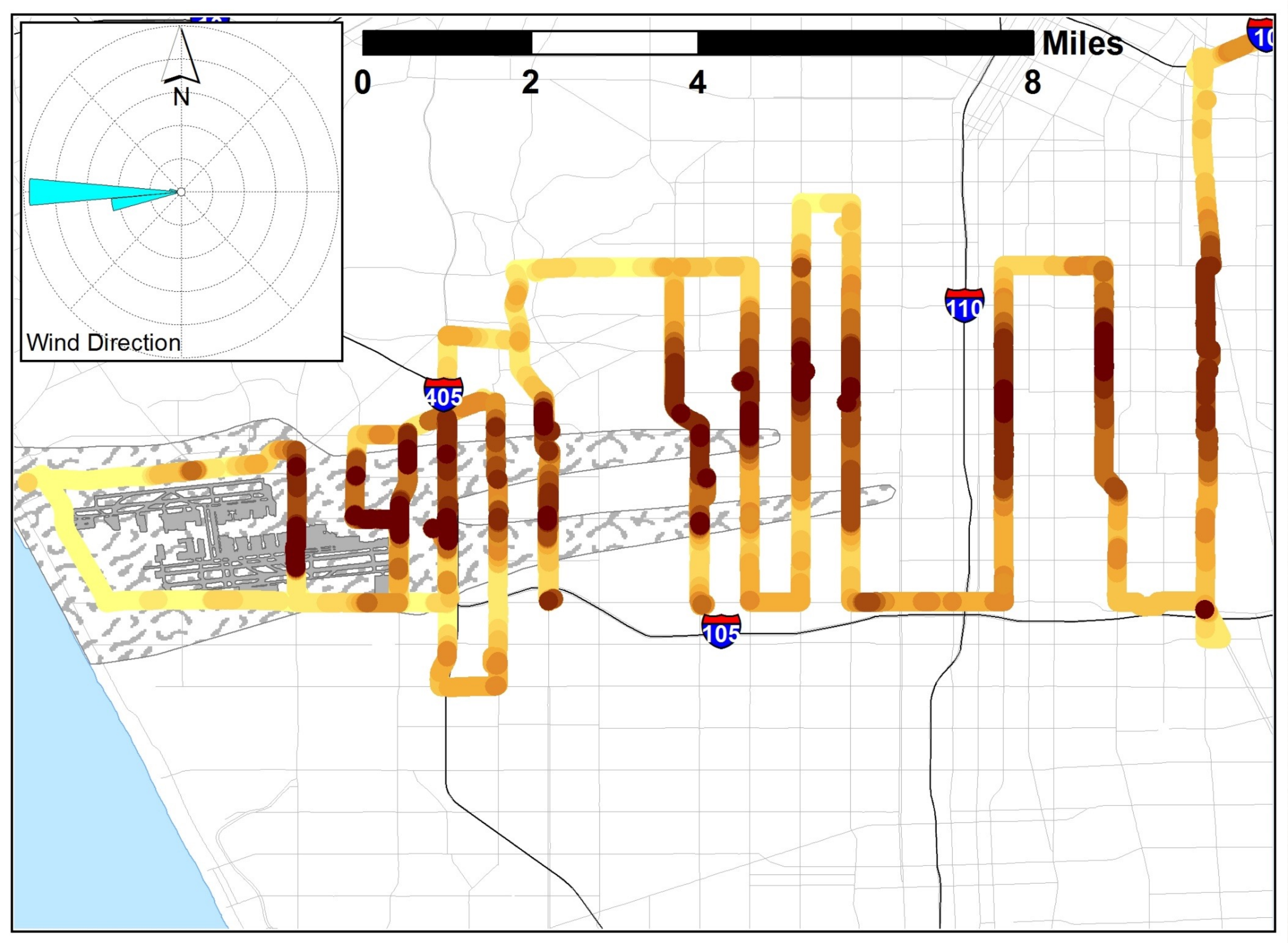
Mobile monitoring of particle number concentrations



100th Percentile

SPATIAL PATTERN

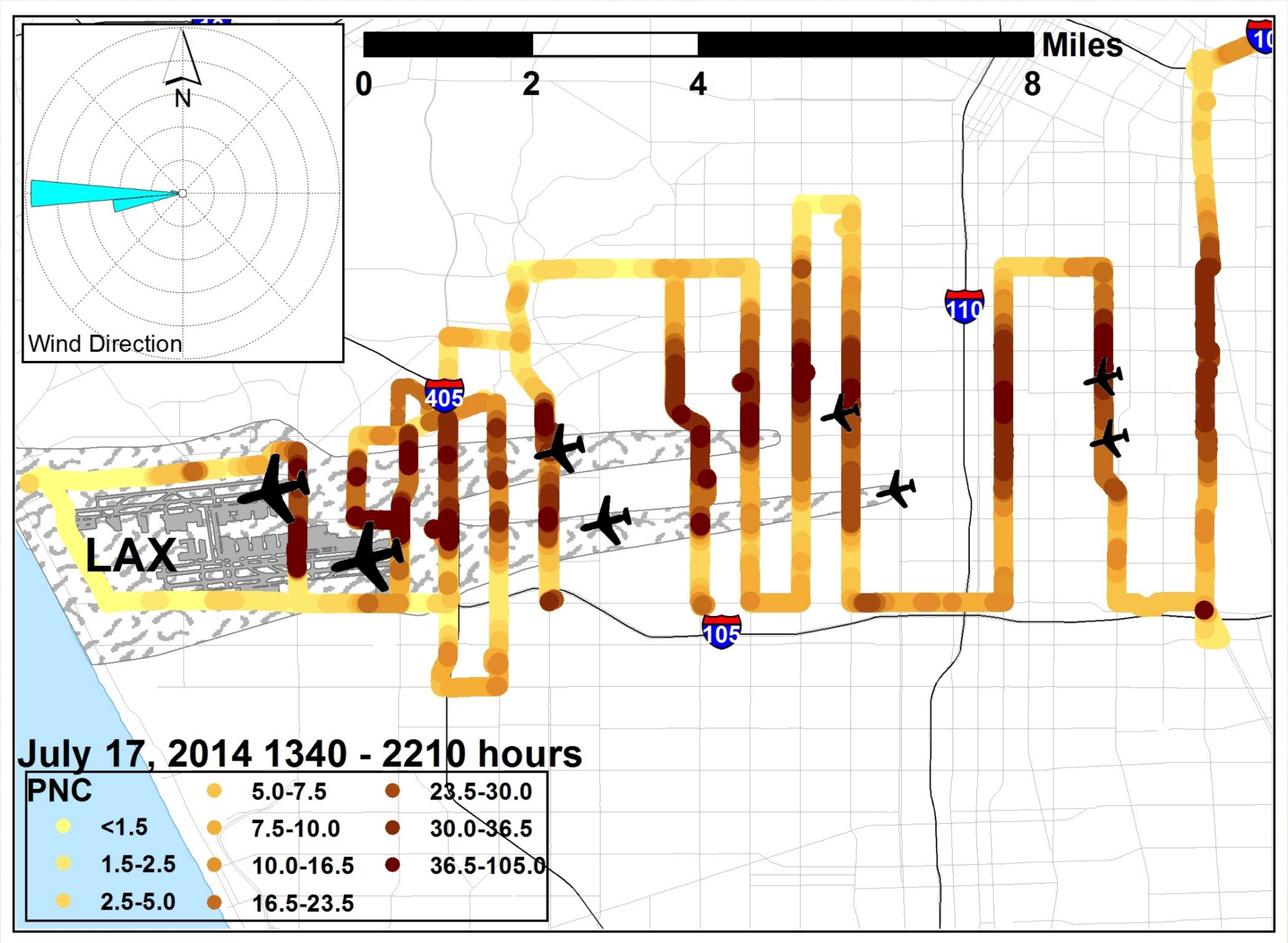
Mobile monitoring of particle number concentrations



SPATIAL PATTERN

Mobile monitoring of particle number concentrations

SPATIAL PATTERN
Mobile monitoring of particle number concentrations

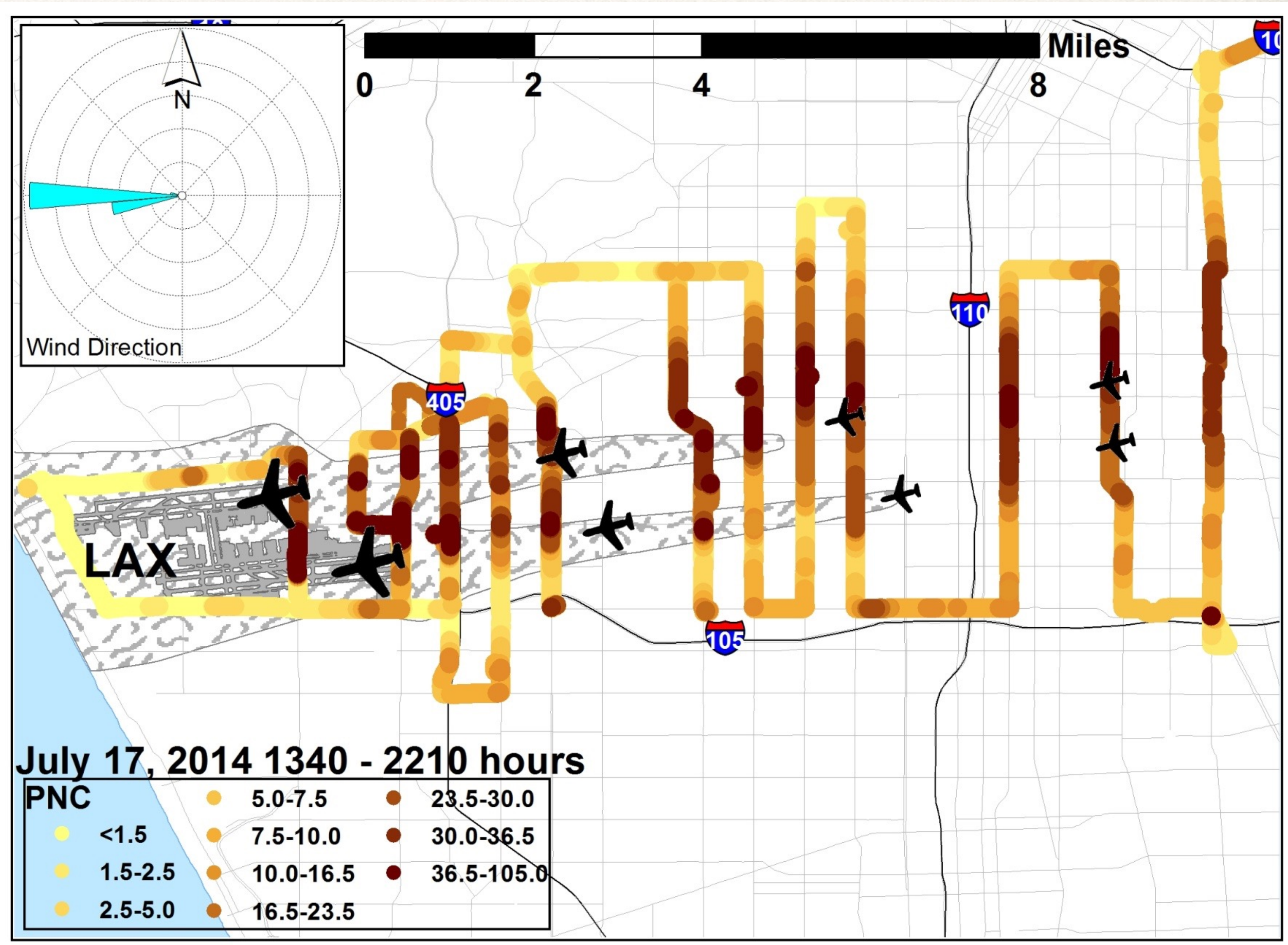


SPATIAL PATTERN

Mobile monitoring of particle number (PN) concentrations

Locations of highest baseline PN concentrations on all transects

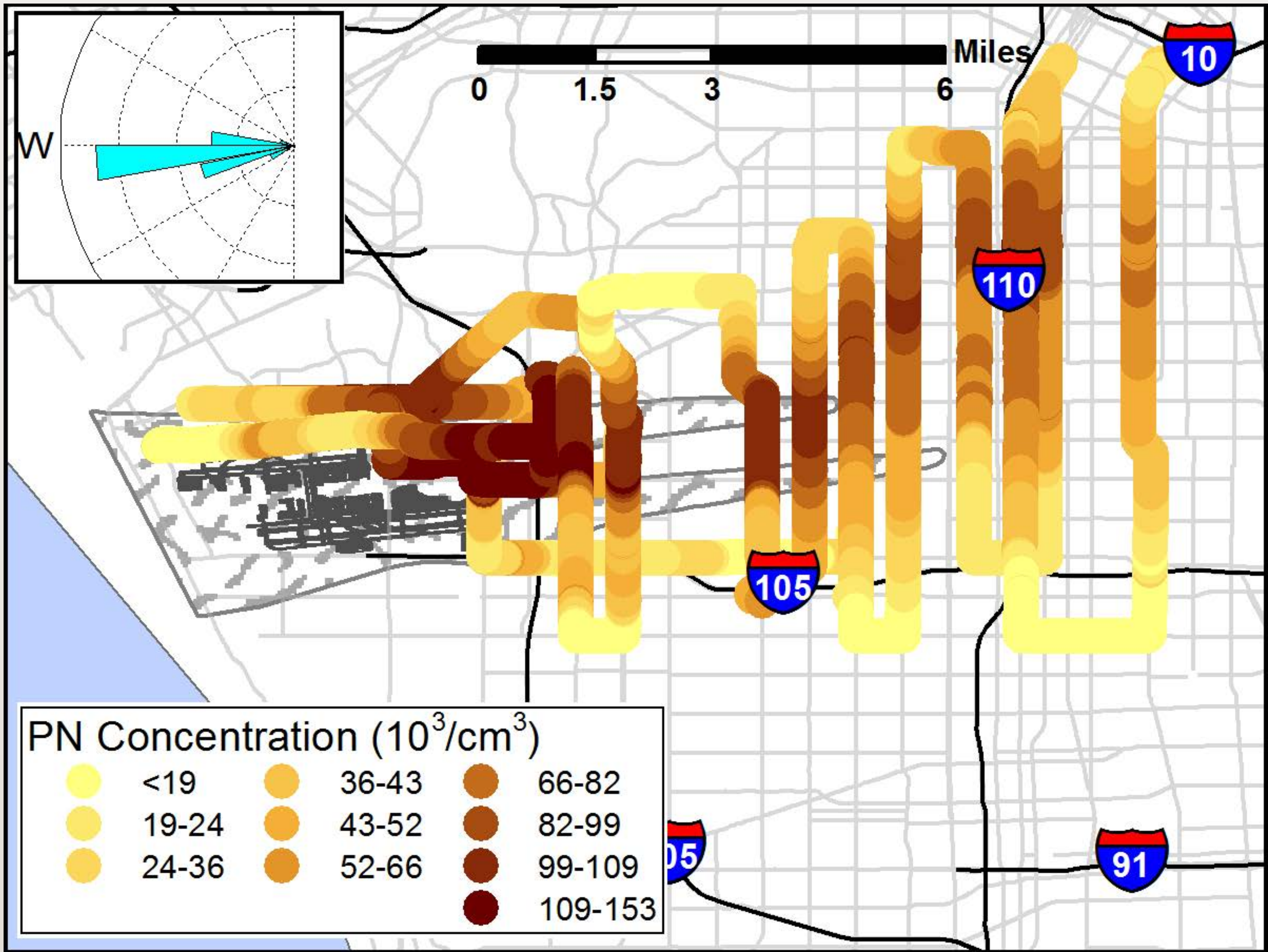
- align to the prevailing winds, and
- the incoming flight trajectory



IMPACT OCCURS REGULARLY

Most hours of the day - all monitoring runs - pattern reflects the day's meteorological conditions

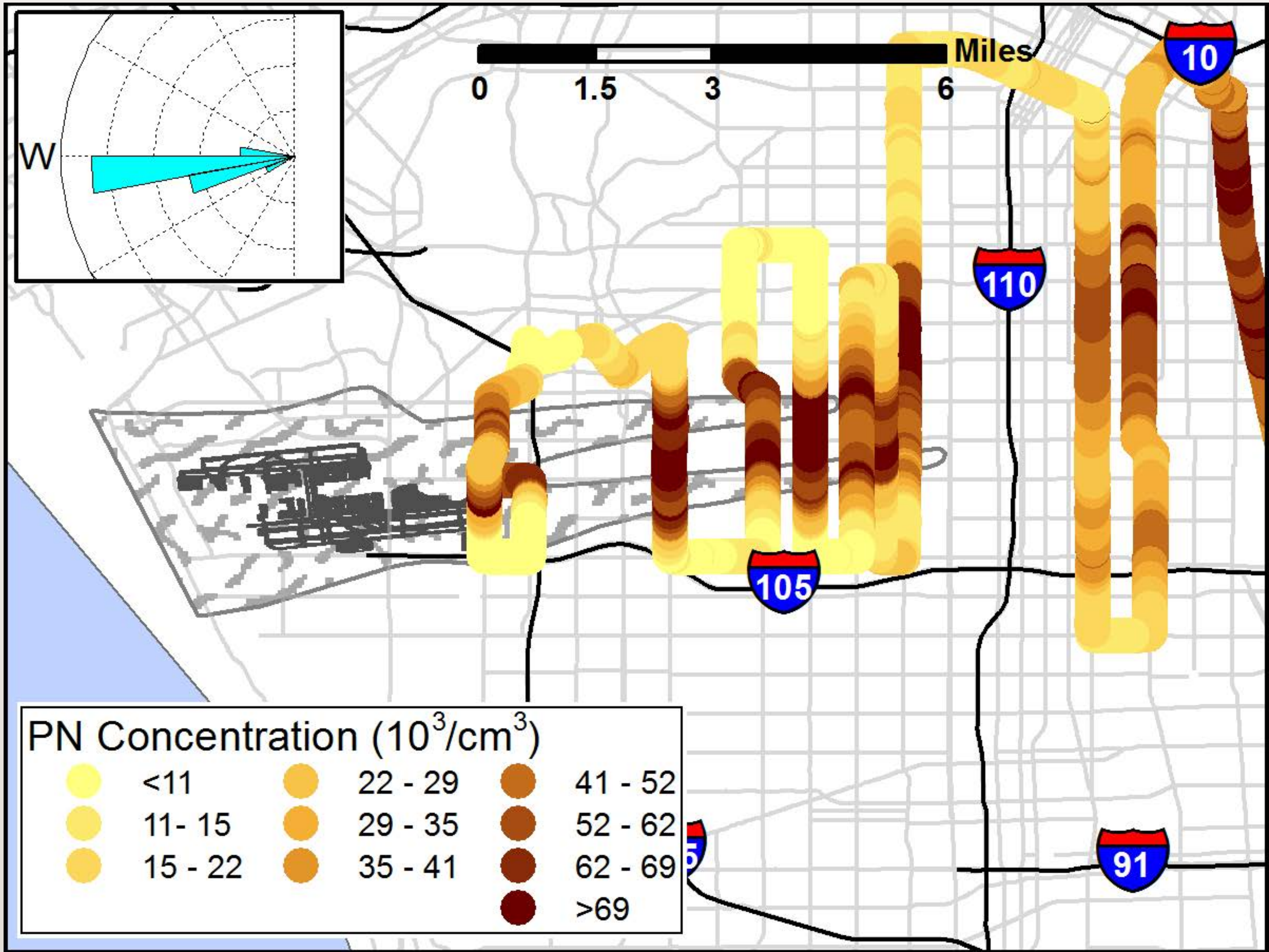
August 15, 2013
0830-1530 hours



IMPACT OCCURS REGULARLY

Most hours of the day - all monitoring runs - pattern reflects the day's meteorological conditions

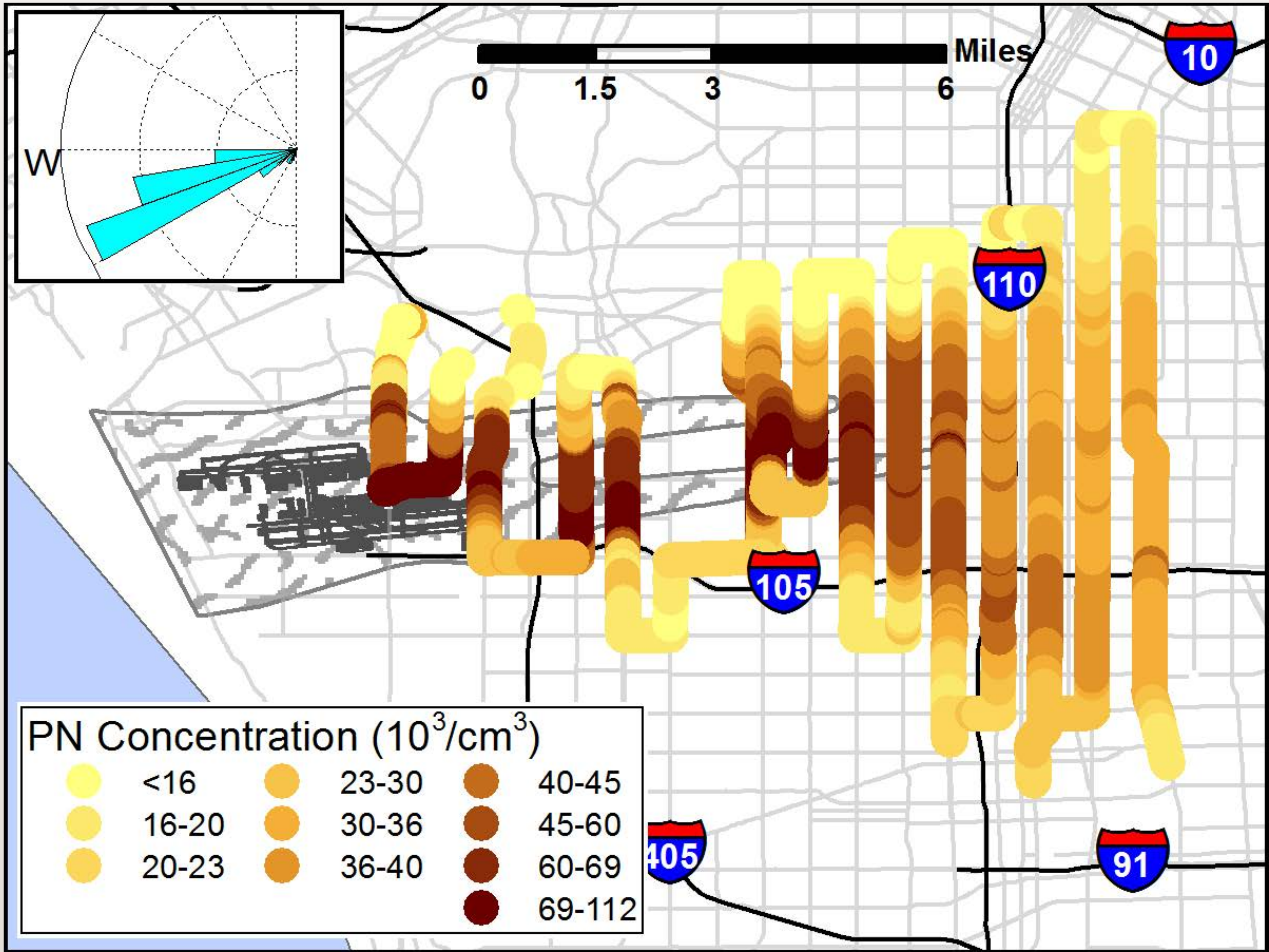
August 16, 2013
0945-2050 hours



IMPACT OCCURS REGULARLY

Most hours of the day - all monitoring runs - pattern reflects the day's meteorological conditions

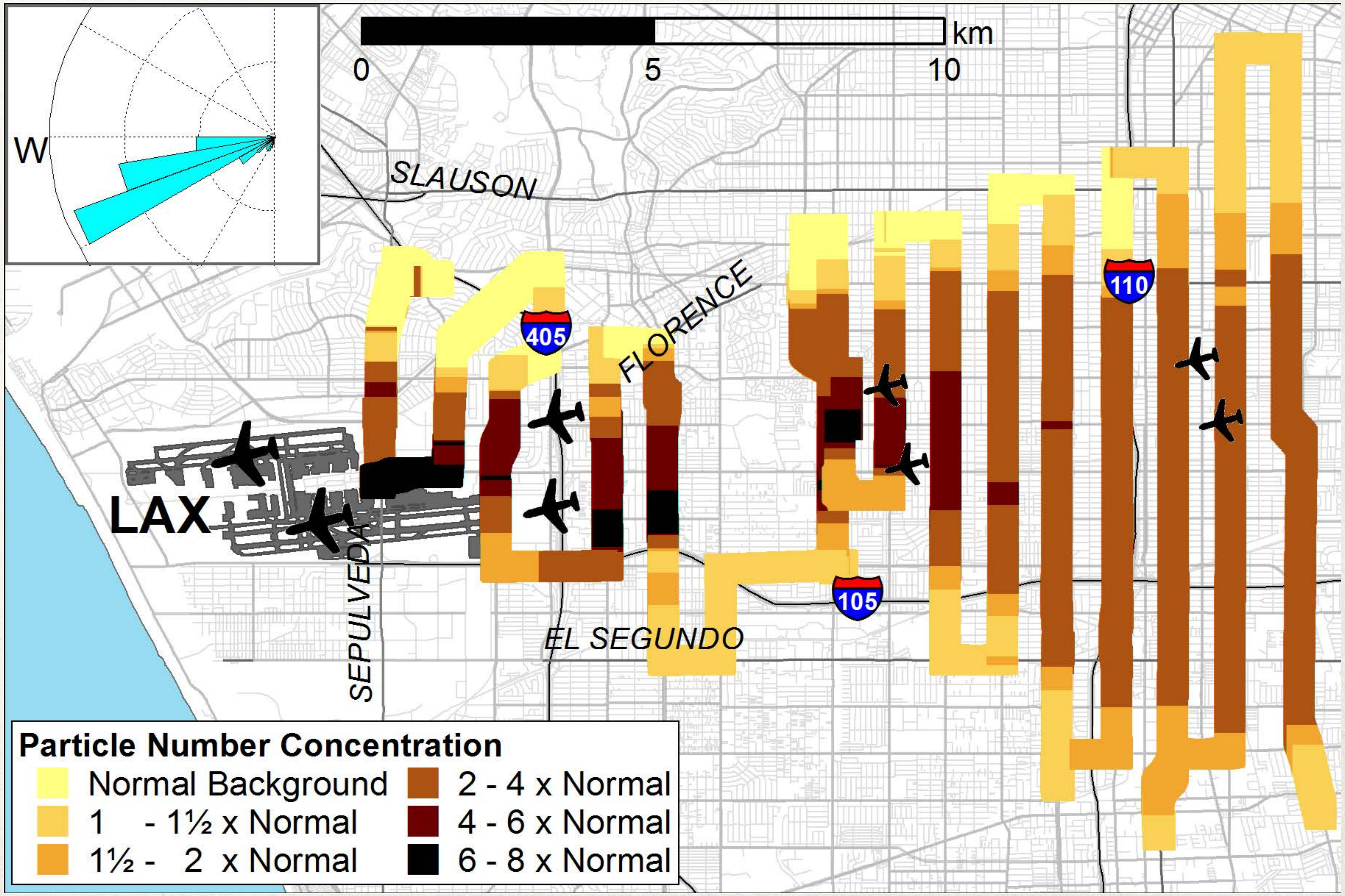
August 23-24, 2013
1200-0130 hours



SUMMARY OF RECENT STUDIES:

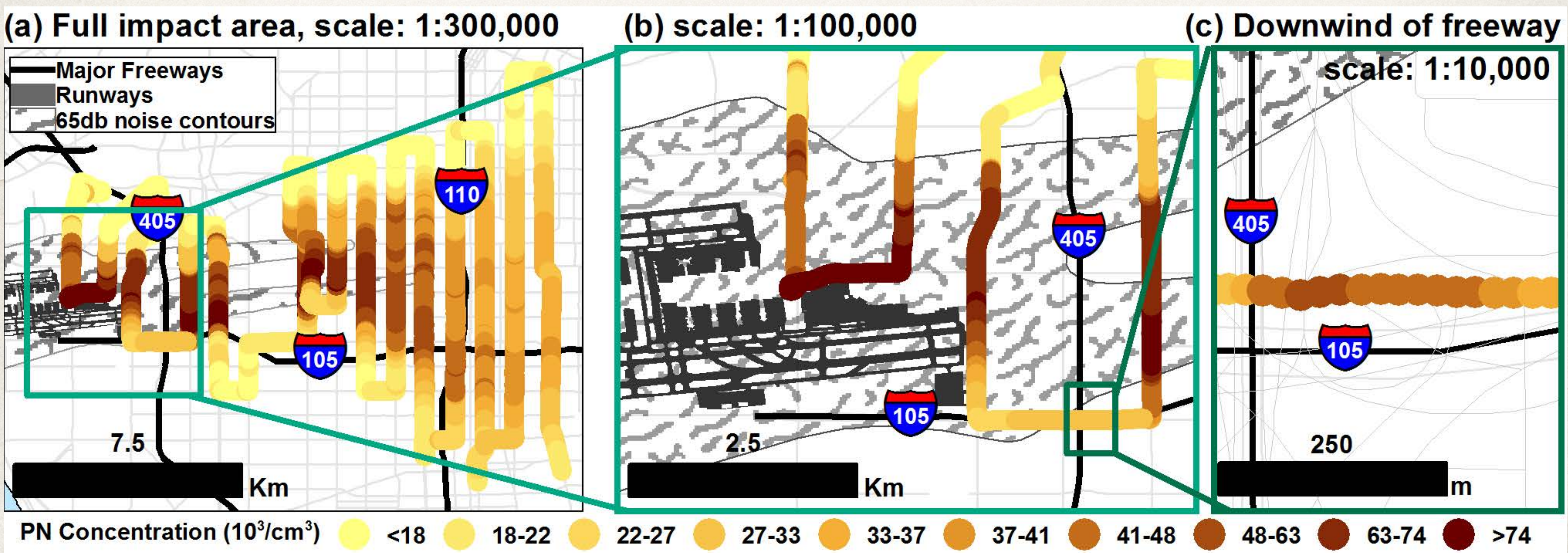
HUDDA ET AL. 2014

- Large Impact Area
- Local = 15 -20 km



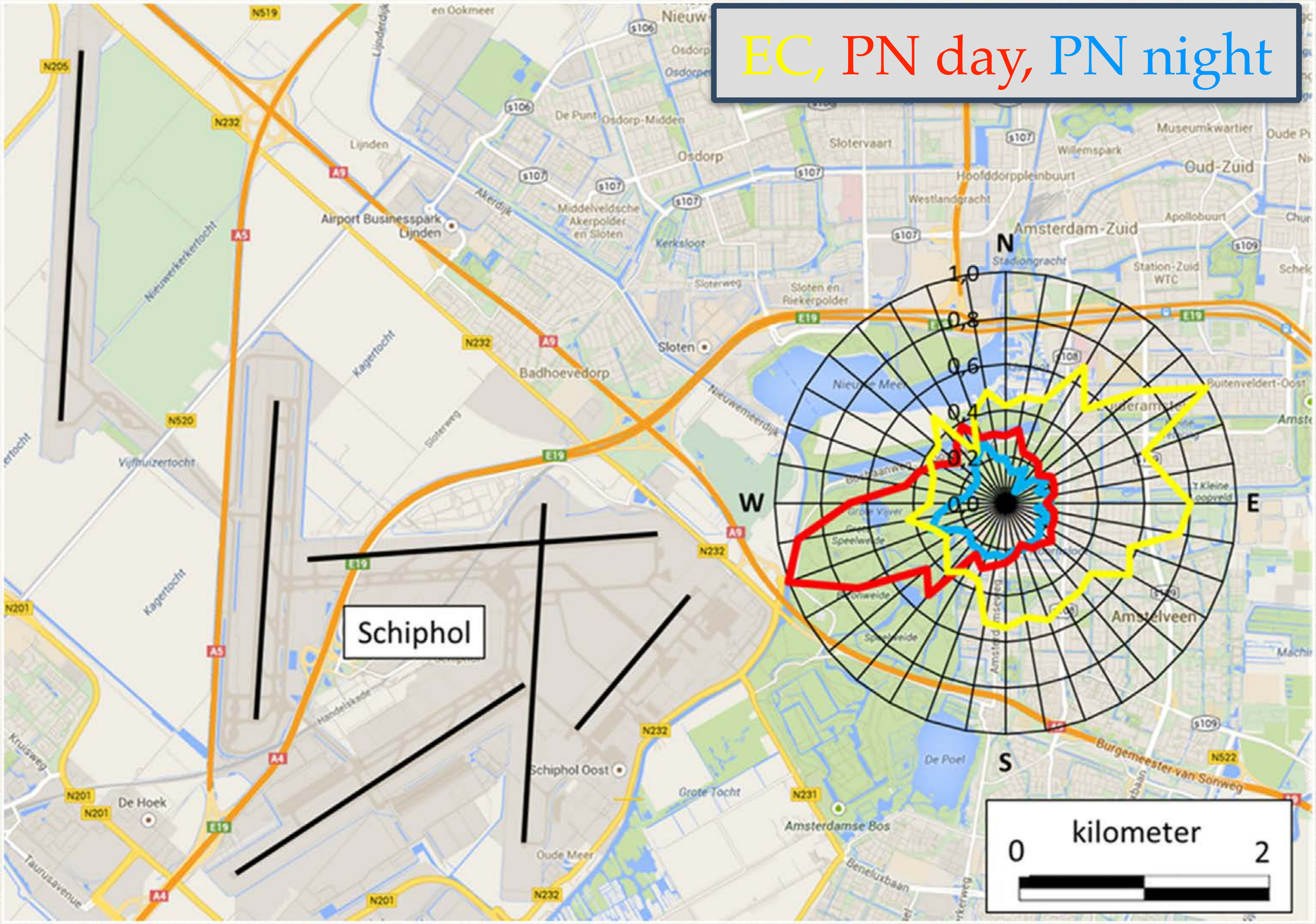
SUMMARY OF RECENT STUDIES:
HUDDA ET AL. 2014

- Large Impact Magnitude
- LAX Impact ≈ 1/4 of that from LA freeways



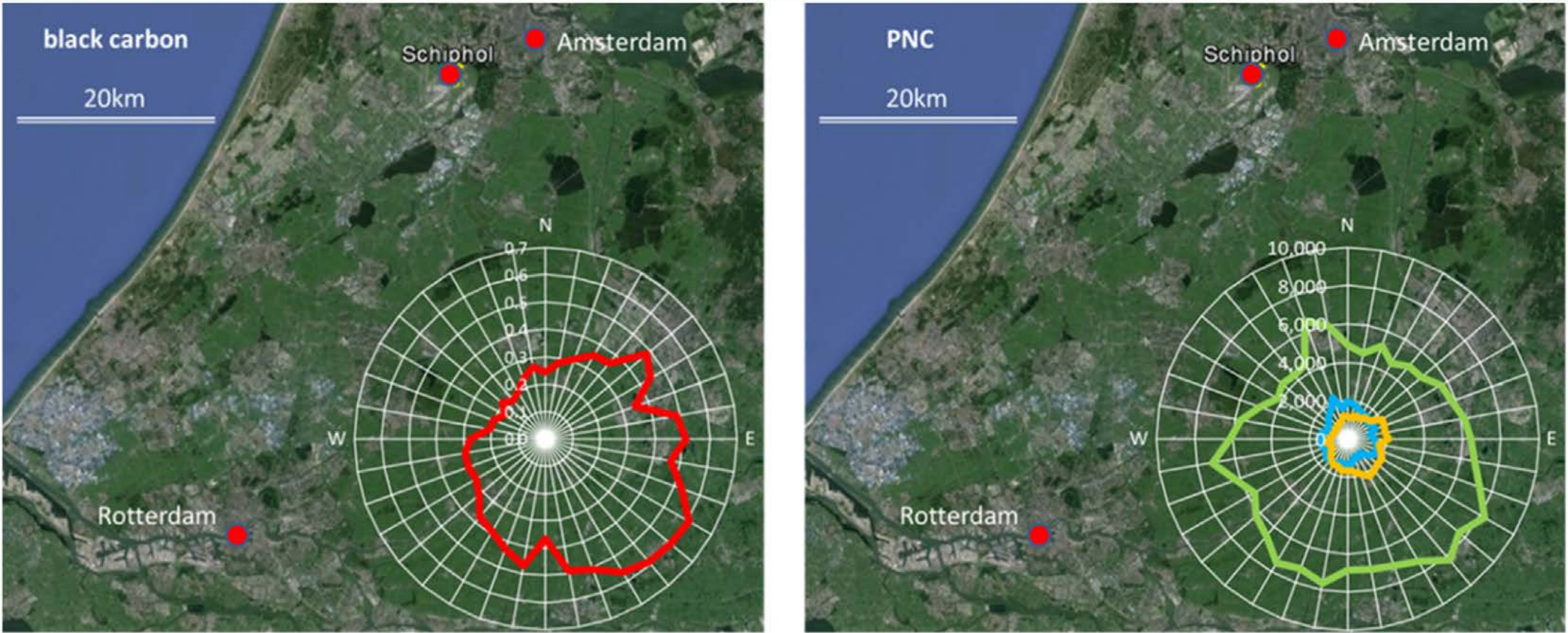
SUMMARY OF RECENT STUDIES:
KEUKEN *ET AL.* 2015

- 2-3 times higher PN when wind is blowing over the airport

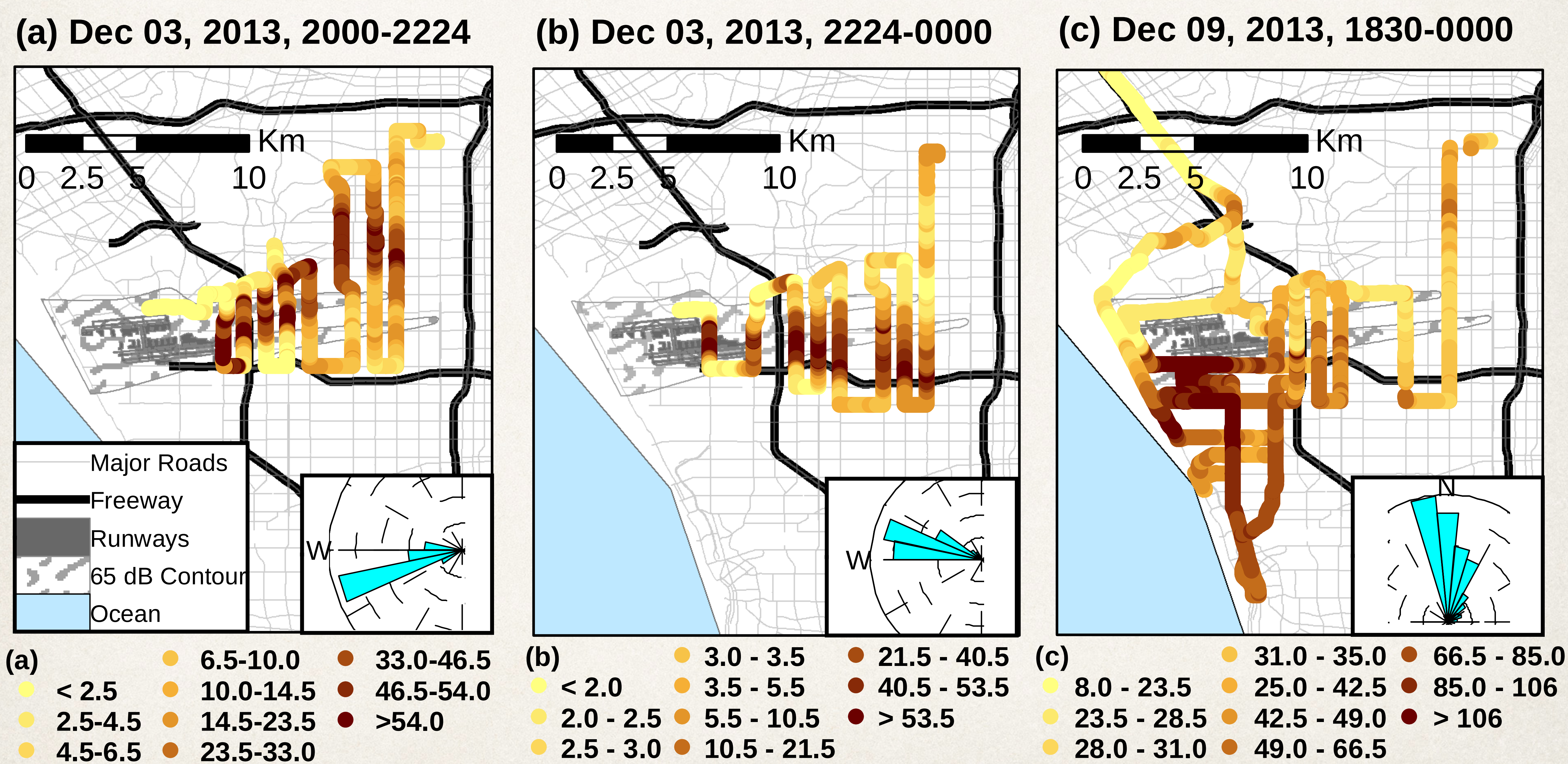


SUMMARY OF RECENT STUDIES:
KEUKEN *ET AL.* 2015

- Impact on PN concentration can be detected at a site 40 km from Schiphol - 20% higher

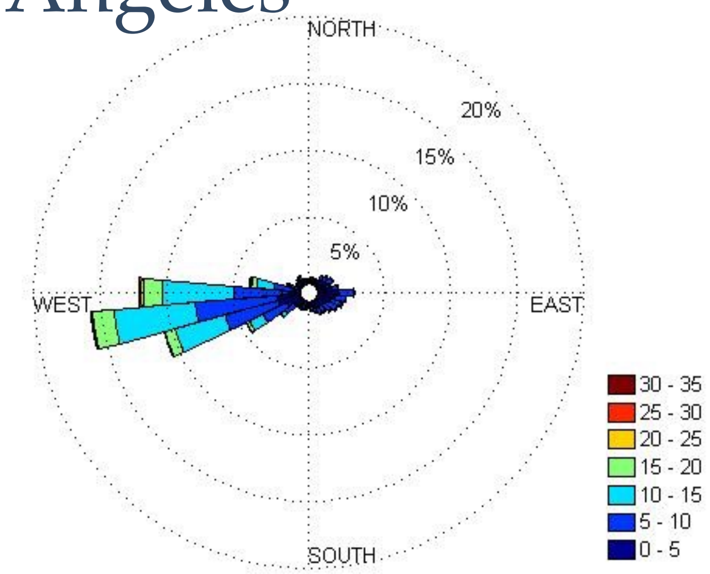


THE WIND DIRECTION CONSIDERATION

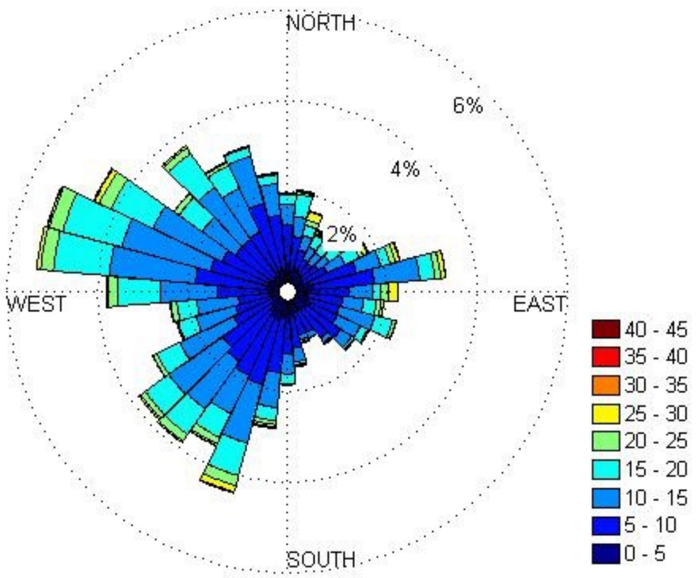


THE WIND DIRECTION CONSIDERATION

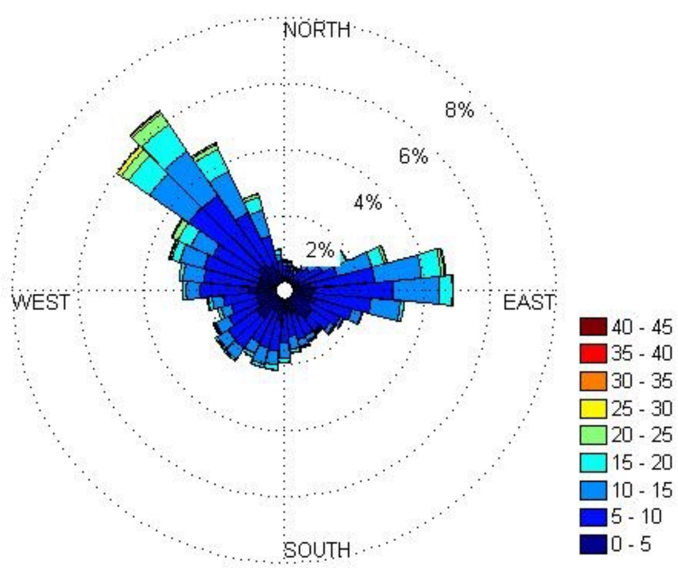
Los Angeles



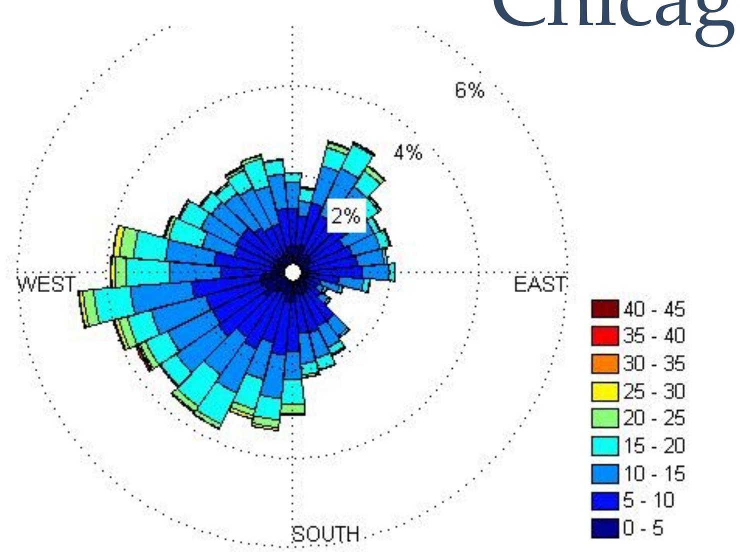
Boston



Atlanta



Chicago



THE WIND DIRECTION CONSIDERATION

- Variable wind direction makes detection of the signal challenging but the signal can be detected
    - A network of sites and longer sampling campaigns needed
    - Mobile monitoring is an efficient alternative

IMPLICATIONS FOR EXPOSURE ASSESSMENT - I *PHYSICAL PROPERTIES*

- Regarding physical properties:
  - Elevated PN are mostly comprised of ultrafine particles.
    - *Keuken et al*. found that 10-20 nm particles dominate size distribution at a site that was 7 km
    - *Hudda et al*. are looking at the spatial pattern of physical properties of this aerosol over the large area
  - 5-10% higher deposition efficiency over urban ultrafine aerosol
- Significant impact in terms of number concentration or **other expressions for assessing ultrafine exposure**, like, **surface area.**

IMPLICATIONS FOR EXPOSURE ASSESSMENT - II *CHEMICAL PROPERTIES, MULTIPOLLUTANT MIXTURE*

- Is this a unique ultra fine particulate matter mix?
  - Sulphur content is not regulated in aviation like in automobile fuel (600ppm vs 15ppm)
  - Characterize a “aviation signature” that includes other pollutants at long downwind distances
  - Signal easily detected in PN concentration; signal-to-noise ratio low in other pollutants, or ?
  - Emission profile different for landing, take-offs, idling - need to quantify contribution of each activity to this impact?
  - Is there a signature mix - does it vary by distance to the source - what are the most important components of the mix from exposure point of view at a large community wide level?

IMPLICATIONS FOR EXPOSURE ASSESSMENT - II *NOISE*

- Residential exposure to aircraft noise has been studied
  - Association with hospitalization, CVD (Correia et al. 2013)
    - Considered PM2.5 and Ozone as confounders
  - Association with risk of stroke, coronary heart disease, and cardiovascular disease (Hansell et al. 2013)
    - Considered PM10 and road traffic noise as confounders
- Both found a significant increase in risk
- **Should ultrafine be considered a confounder in future airport studies or is it an opportunity to study health risks of ultrafine?**

IMPLICATIONS FOR EXPOSURE ASSESSMENT - III ULTRAFINE RISK

- An opportunity to study ultrafine health risk
    - Large subject population
    - Chronic exposure - possible cohort
    - Relatively stable acute exposures
- Consider airport-related emissions as an explanatory variable for past studies and improve previous models

IMPLICATIONS FOR EXPOSURE ASSESSMENT - IV MODELLING EXPOSURE

- Inclusion in Land Use Regression models
  - Distance to airports, Deviation of prevailing wind direction from azimuth to the airport/active runway, Flight Activity, etc.
  - A combination of several variables required to truly capture the impact
  - Example, *Weichenthal et al. 2015.*
    - Included distance from Pearson airport in Toronto; R2 was 0.22, 0.26 for single predictor model
    - "suggests that airports have a measurable impact on ambient UFPs after adjusting for other factors, including proximity to highways and major roads."

ACKNOWLEDGEMENTS

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Special Mention:
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