**Urban heat island implications from parking, roads, and cars: a case study of metro Phoenix**

**Parking, roadways, and cars oh my: urban heat island implications of automobile dependence in metro Phoenix, Arizona**

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# **Abstract**

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**Key words:** parking; urban heat island; infrastructure; Phoenix.

1. **Introduction**

* General background on UHI
* Background on Phoenix including growth & prevalence of UHI
* Background on transport infrastructure’s influence on UHI (vehicles, pavements)
* Background on Phoenix in context of auto-centricity, sprawl, parking growth, etc.
* Establish gaps, intro research q’s

The major issue with parking and UHI is parking is directly related to land use and therefore building types, thus making it hard to determine the influence of parking infrastructure on UHI unless there is a way to control for land use and building development.

**Research Questions**

* What are the current (and possibility historical) impacts on urban heat island by transportation infrastructure (road pavements, parking pavements, and vehicle waste heat) in Phoenix?
* Are there any local heat islands in urban metro Phoenix that are driven by most by transportation infrastructure (rather than buildings, and non-vehicle waste), and are there any notable transport infrastructure designs that contribute to this (e.g. parking lot design/locations, narrow roads, lower vehicle traffic, etc)?

1. **Methodology**

**To assess the current influence of transport infrastructure on Phx UHI, two approaches:**

1. Part A: Temporal and spatial changes in historical land surface temperature in metro Phoenix are compared with changes in parking pavement density, and roadway density with controls for building density and type, and greenspace density using geospatially weighted regression (GWR) to determine the influence of transportation infrastructure on urban heat island. Additinally, the influence of automobile travel on current urban heat island in Phoenix, travel data are used to quantify vehicle waste heat in the form of heat flux around urban roadways (e.g. updated data from MAG model, 2017 NHTS). Historical analysis such that change in parking + pavement density is regressed on change in measured urban heat (after adjusting for seasonality, etc.)
   * **Pros:** Informs influence on UHI. Somewhat straightforward data requirements and modeling that I have experience in doing. Should only need satellite data for LST, potentially land cover/use data.
   * **Cons:** Less robust in assessing *direct* influence on UHI (LST is a proxy, and regression is an relational estimate). Probably would need to control for other non-transport related influences on UHI. Split into two separate parts that are not commensurate for UHI influence (LST and pavements vs. heat flux from vehicles).
2. Model heat flux of transport pavement and heat flux of vehicle movement to inform influence on UHI.
   * **Pros:** More robust in assessing influence to UHI. Can include pavement and vehicle effects in commensurate output (e.g. watts/m2).
   * **Cons:** Requires more comprehensive set of data and more advanced heat storage modeling (e.g. need air and surface temps, wind, dew, pavement properties, etc). Requires data at high spatial resolution which might be difficult to obtain (or doesn’t exist in ideal format). Heat flux is not temperature or thermal comfort, so direct effects on outdoor individuals directly from transport infrastructure will likely remain unclear.

**General Questions**

* Could assessing historical changes in temperature relative to development of pavements with controls for other influencing variables be useful?
* What data and at what scale could be used? E.g. Landsat 7 & 8 data recorded every few weeks from ~2000 to current at 30x30m? Would that be realistically useful? If not is there anything better?
* Any papers or materials that are relevant?
* What models or datasets exist that could be useful for this research? E.g. Highest spatial resolution weather data? Are we limited to two dozen weather stations plus 30x30m LST?
* Is it reasonable to model heat flux from a pavement at a city level at a moderate resolution (e.g. 30x30m)?
* Is it reasonable (or even possible) to approximate the influence of parking pavement, roadway pavement, and vehicle waste heat on urban heat island without doing a comprehensive UHI study on all factors? In other words, if I don’t include building waste heat, roof materials (albedos), is it possible to comment on UHI from other sources (i.e. just estimate heat fluxes)?
* Relative to a baseline (nearby rural measurements) what amount of increased near surface temperatures intersect with highest densities of roadway pavements? Could I comment on roadway pavement plus vehicle waste heat create bias in near surface air temperature measurements?
* First step is to convert Phoenix parking inventory into useable format for estimate impact on UHI:
  1. To estimate more exactly the surface cover of parking, calibrate the total coverage area to estimated surface coverage area: if the area of parcel building + area of parking required (with access ways & handicap spots) is greater than the total parcel area, assume some amount of spaces are effectively surface cover vs not.
* **First approach: estimate urban heat flux storage on or due to parking and roadway pavements and heat flux due to vehicle travel (ICARUS model)**
  1. Likely requires high resolution air temperature data on a compensate scale with parking/roadway data (e.g. sub 100m?)
  2. Solar radiation estimates needed, but limitations include the interference of buildings, trees, and other obstructing infrastructure.
* **Second approach: measured LST (satellite) vs. estimated pavement temperature or pavement coverage.** 
  1. Major downsides:
     + LST is proxy for UHI
     + Air temp is more relevant for thermal comfort.
     + Using only pavement density will be problematic because of course where there is more pavement, there will be higher surface temps.
     + How to tease out non-pavement surfaces? Controls in fixed effects model?
  2. Upsides:
     + Regression model could be used to test mitigation approaches, e.g. what happens if we reduce parking requirements, slim roads, or penalize heavy traffic?
  3. Retrieve high spatio-temporal weather data (air temp, solar rad, dew, and wind at near-hourly temporal resolution and near-parcel level spatial resolution).
     + What data is available? Ari’s solar measure measurements + ?
  4. Assume a confidence interval of parking pavement albedos. Most are assumed low albedo asphalt pavement. For parcels where parking garages are assumed required, assume high albedo concrete pavement.
  5. Estimate the surface temp of parking lots across the region via Gui et al. (2007) approach with weather data.
  6. Regress estimated parking pavement temperatures onto measured LST across metro region.

1. **Results**

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1. **Discussion**

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1. **Conclusion**

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**References**

Gui J, Phelan PE, Kaloush KE, Golden JS. 2007. Impact of Pavement Thermophysical Properties on Surface Temperatures. J. Mater. Civ. Eng. 19: 683–690.

* Need to have reasonable estimate of asphalt vs. concrete. eager undergrad to help classify
* Verify by sampling. e.g. parking lots are parking lots are 92% asphalt
* Some way to account for shade free services. if you have two pavements with different lst
* reflected radiation is important, can't ignore if want to comment on human thermal comfort
* parked cars in front can be attractive
* 100+ fixed weather stations reporting air temperature in phoenix. less accurate. if you have enough, uncertainty is less of a concern
* satellite image classificaiton
* Morning vs night??
* compare week day vs weekend
* compare peak traffic to offpeark
* radius of influence, what fraction of circle around air temperature readings
* percent concrete vs relative delta t
* RMSE or fit -> change the raduis of influence, look for other papers
* windy vs calm day could also influence
* max, min, hourly, moving avg, for temps
* include traffic in regression
* Every sq ft of pavement and/or car increases air temperature by x amount.
* could also try ndvi as part of control, or is in a tight row
* regression tree -> where there’s high veg here's the regression relationship
* Yannik, D Sailor postdoc - email him if i want to talk about phx temp data - what’s more trustworthy
* past research sailor, traverse measurements
* Melisa hart + sailor paper, from satellites we can get albedo, veg surface, ect. total building good methodology guide