

URBAN HEAT ISLAND EFFECT

BAKERSFIELD, CA (2013-2023)

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RESEARCH QUESTION

How has the urban heat island changed across Bakersfield, CA from 2013-2023 as the area has undergone urban growth?

BACKGROUND

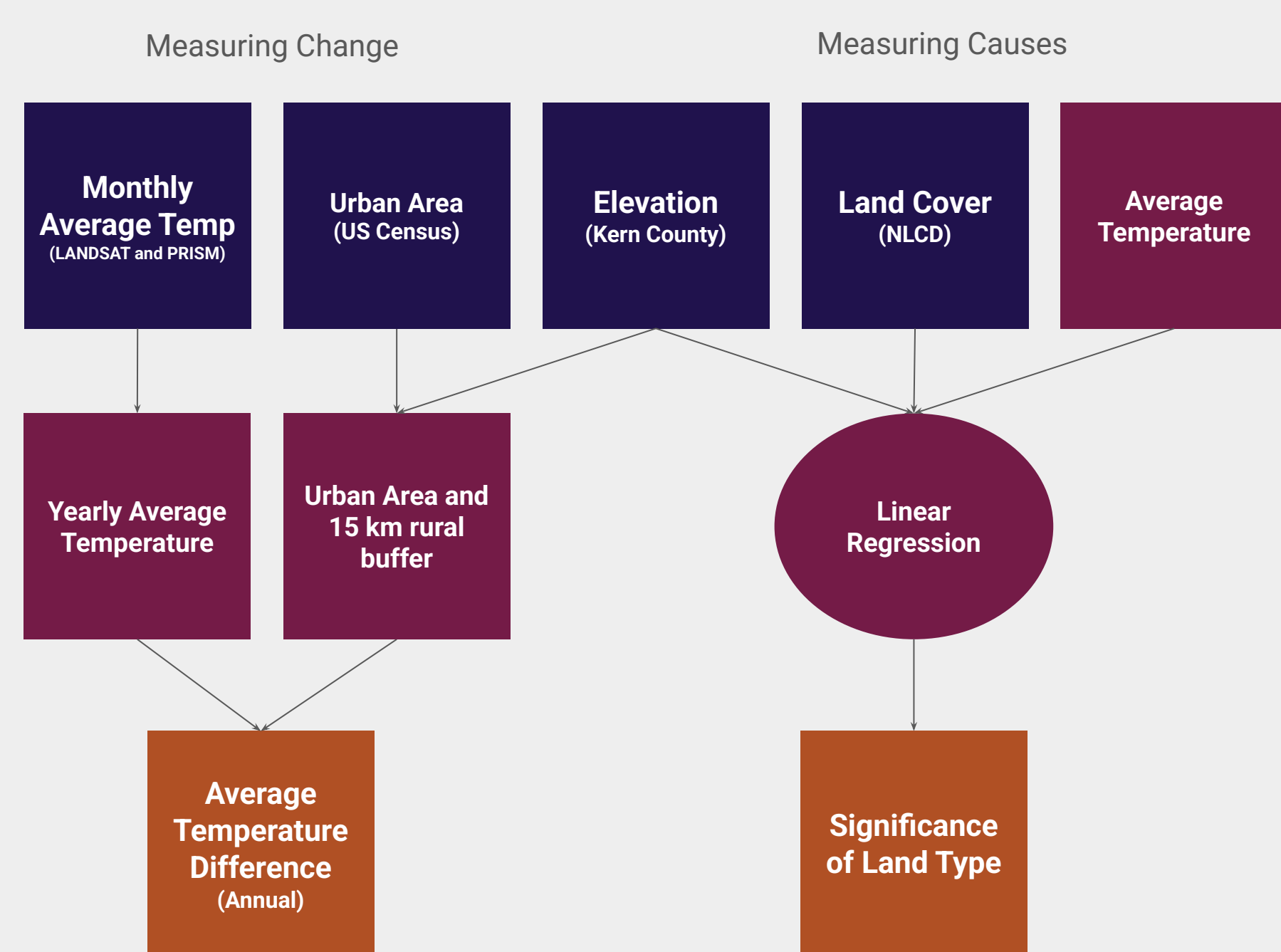
The Urban Heat Island Effect

The urban heat island effect (UHI) describes how temperatures in urban areas are elevated as a result of human development such as impervious surfaces that absorb and retain heat from the sun, reduced green spaces, and a concentration of human generated heat¹. Heat related deaths have been increasing in the US², so it is import to mitigate UHIs when planning out cities and GIS serves as a helpful tool in examining specific areas of interest.

Why Bakersfield?

The population of the Bakersfield urban area is approximately 920,000 as of 2024⁷. The area is growing much faster than California at large, with the population quadrupling since 1980. Also, Bakersfield has a hot summer climate and can serve as a catalyst for examining other cities throughout the Central Valley region of California.

METHODS



Measuring Change

Our primary methodology was implemented in order to measure the year-over-year change in the magnitude of the UHI. This was done starting with TIGER Line shapefiles, which are created after the census to define urban areas⁷. Around the area of Bakersfield we created a 15 km buffer¹ representing the rural area, excluding areas above 305m of elevation. Since the census is only conducted every 10 years, we used the 2010 census for 2013-2015 and then used the 2020 census for the remaining years. From here we took the difference between the two average temperatures, once using land surface temperature from LANDSAT 8^{3,4} and again using estimated air temperature from the PRISM weather data⁵.

Measuring Causes

After determining the magnitude of the UHI, we wanted to be able to identify causes. For this, we used OLS regression based on land cover type and controlling for elevation to be able to identify which types of land cover and more specifically, human development, significantly affect temperature.

STUDY AREA

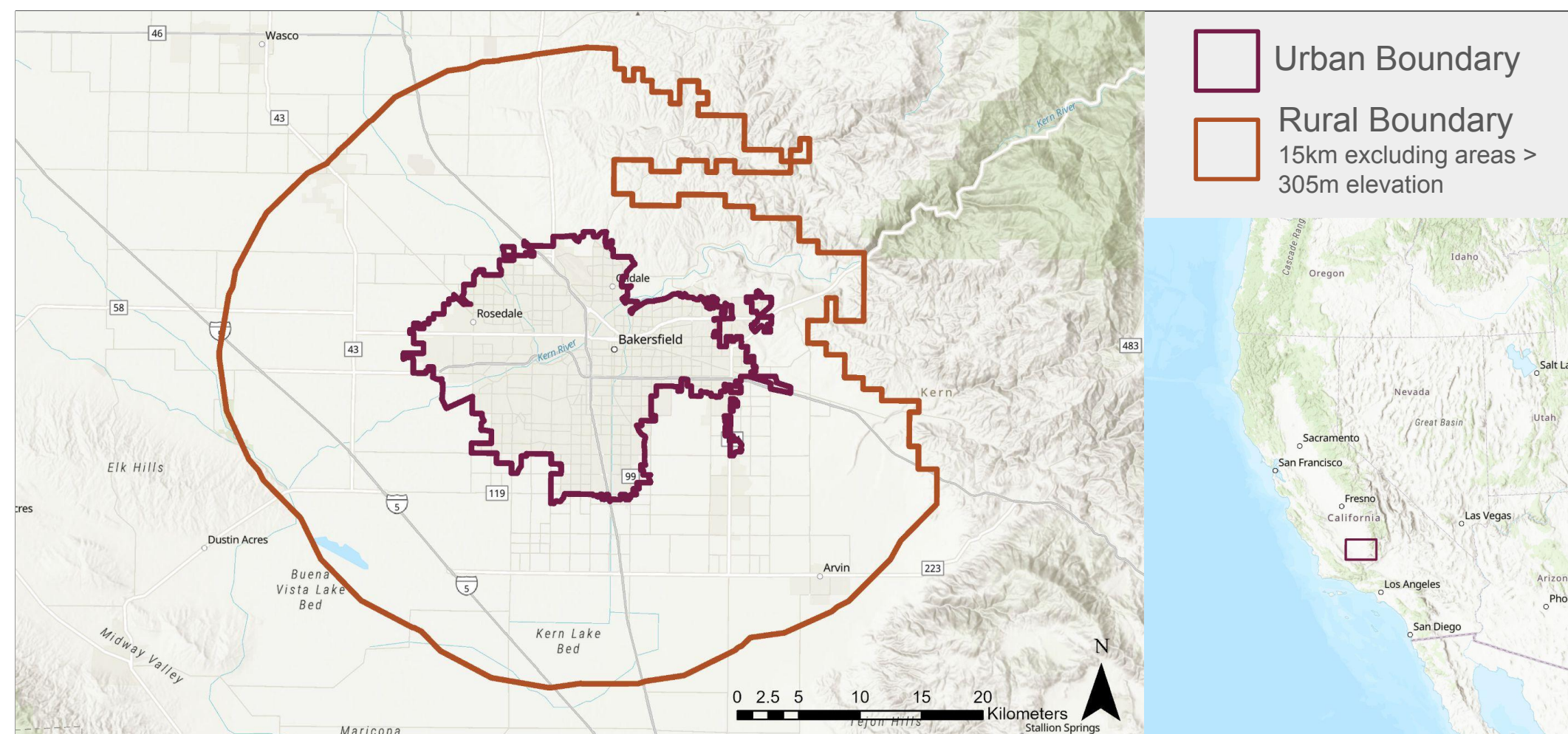


Figure 1, Study area extent

RESULTS

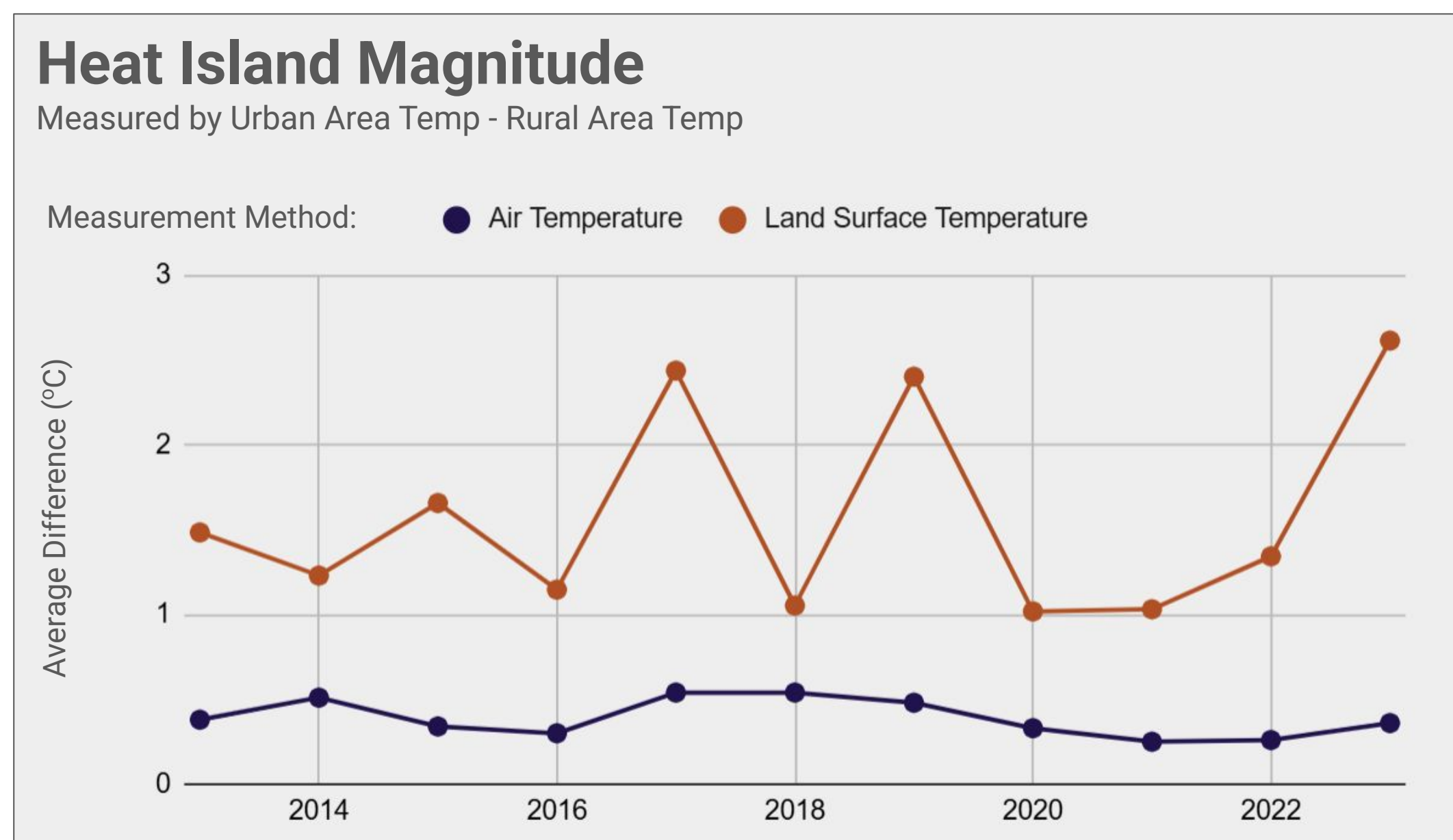


Figure 2

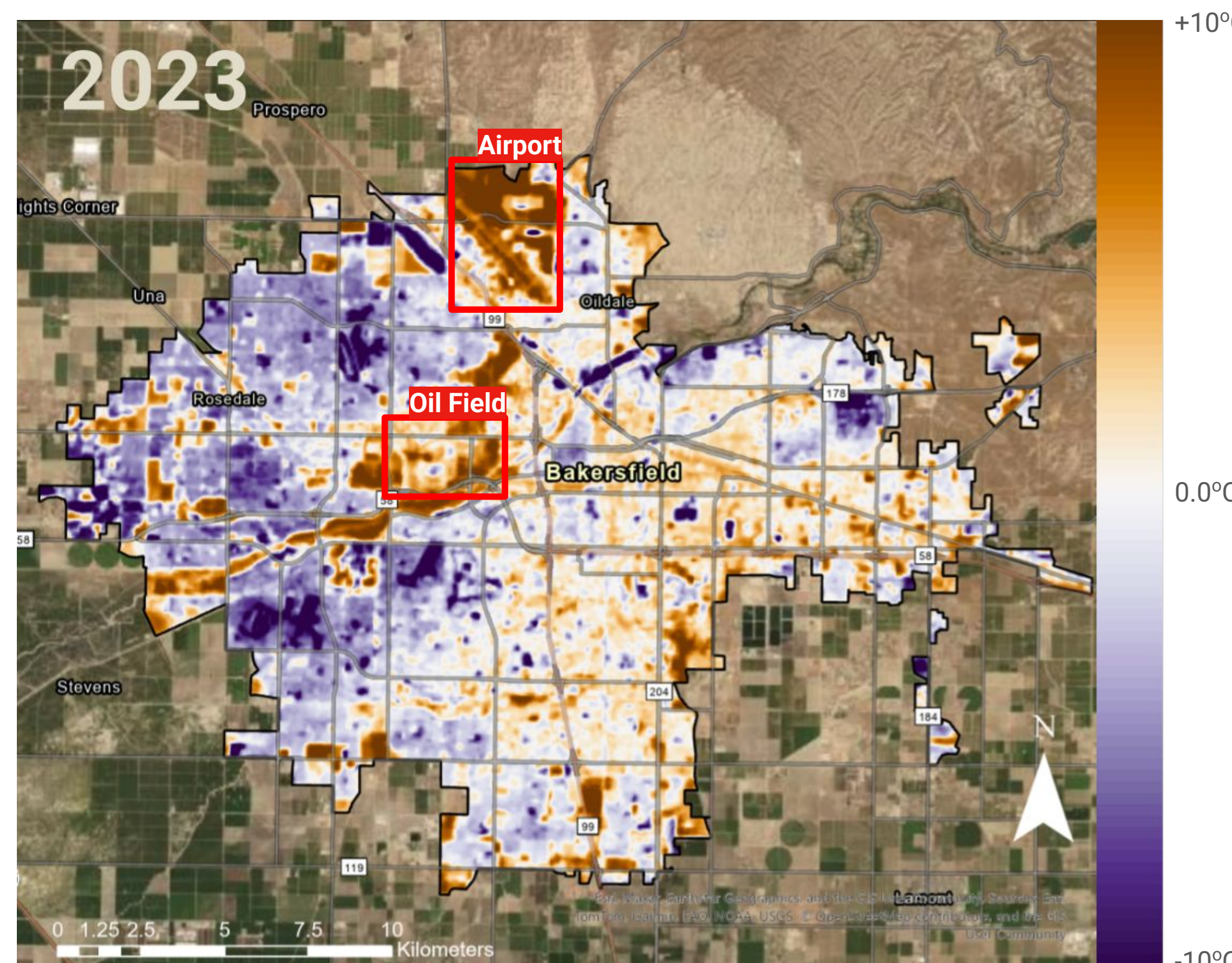


Figure 3, temperature difference from rural area

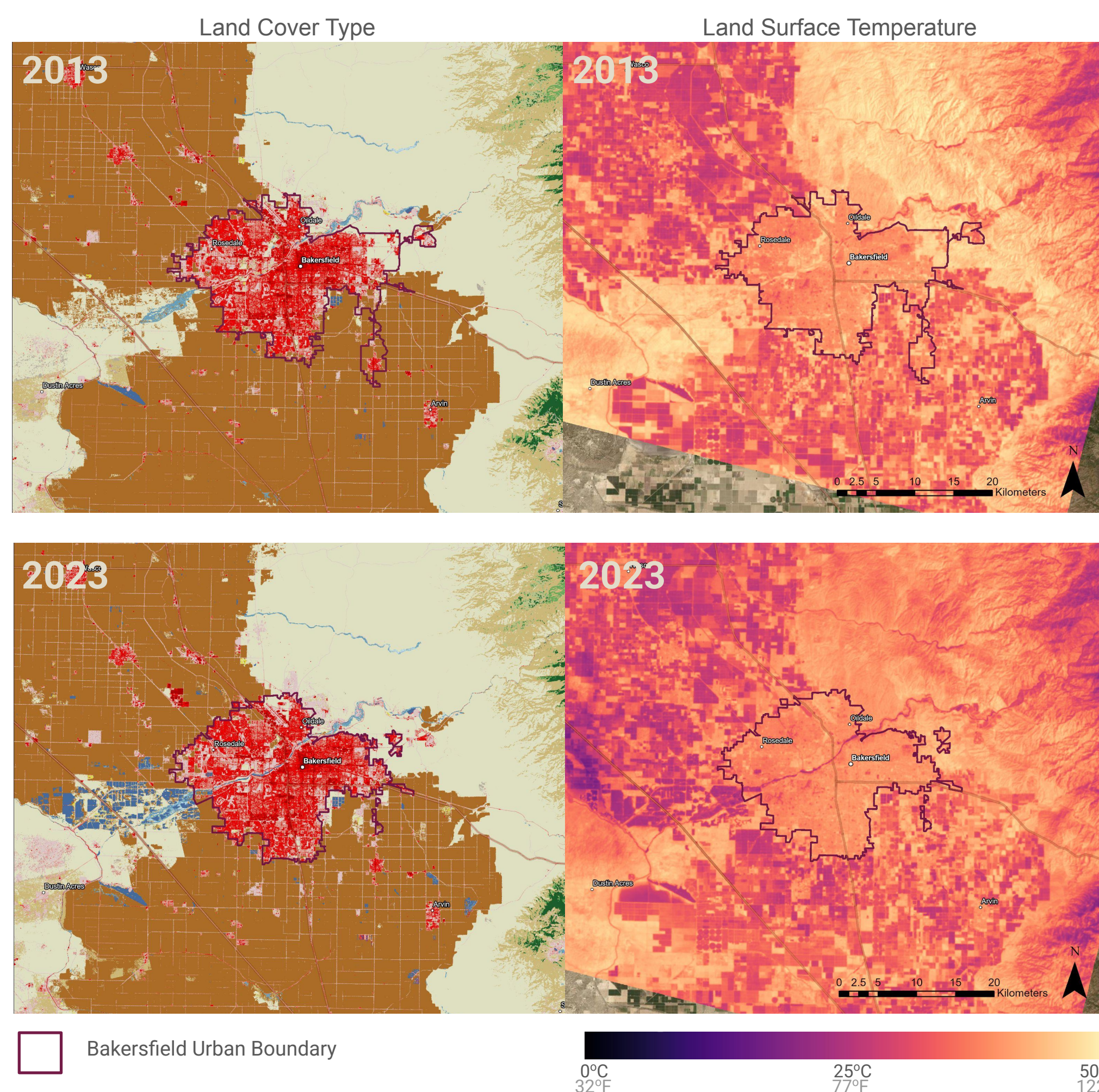


Figure 4, land cover types and land surface temperature

Land Cover Type (NLCD Code)	Coefficient (2013 LST)	Coefficient (2013 Air)	Coefficient (2023 LST)	Coefficient (2023 Air)
Grassland (71) (Reference)	0	0	0	0
Developed Open Space (21)	-6.5***	-0.041	-2.3***	-0.49***
Low Developed (22)	-6.6***	0.19***	-2.4***	-0.55***
Medium Developed (23)	-6.5***	0.51***	-1.9***	-0.27***
High Developed (24)	-5.2***		-1.1***	
Farmland (81 / 82)	-9.98***	-0.20***	-5.8***	-1.0***
Open Water / Wetland (11 / 90 / 95)	-8.2**		-11.7***	-0.84***
Significance codes (p-value):	< 0.001 *** < 0.01 ** < 0.05 *			

Table 1, linear regression coefficients

RESULTS

1. We confirmed that **Bakersfield does have an Urban Heat Island**, but we surprisingly found that the magnitude of the temperature difference is **not significantly changing year-by-year** (Figure 2). This indicates good urban planning.
2. Figure 3 shows that the coolest neighborhoods (heat sinks) have **golf courses and swimming pools**. The hottest areas are large open spaces with **dry vegetation or pavement**, like Meadow Fields Airport and the oil field next to the Kern River. This is evidence of how UHIs are closely tied to wealth. While it may be tempting to recommend building more golf courses, Bakersfield has limited water resources.
3. **Farmland surrounding Bakersfield is relatively cold** compared to the natural grassland (5-10°C cooler). The cooling effect of irrigated land is studied but often overlooked in favor of studying UHIs⁶.

DISCUSSION

General Solutions

Some conventional mitigation strategies for Urban Heat Islands include creating urban green roofs, building additional parks, adding trees, and creating man-made lakes. Additionally, short-term mitigation efforts regarding UHI include cooling centers, warning systems during heat waves, hydration centers, and educating at-risk populations about heat-related health consequences.

Specific Recommendations

- **More neighborhood parks.** These provide cooling effects similar to the golf courses while being publicly available.
- **Continue to irrigate the agricultural land near the urban boundary.** It is essential that land is either developed or continues to be farmland since open space contributes to heating.
- **Preserve water resources.** Drought has potential to limit Bakersfield's ability to cool off with greenspace, so the city must use its water tactically.

Limitations

- **Limited temporal scale**
 - Only 10 years of change
- **Urban and rural area boundaries are arbitrary**
 - Census definition changed between 2010 and 2020
 - Followed the recommendation of 15 km for the rural area¹, but this and the 305m elevation cutoff were arbitrary decisions
- **Surface Temperature vs Air Temperature**
 - Air temperature is what generally affects humans, but it is hard to measure (our data is interpolated and is still at 4 km resolution)
 - LST isn't as good of an indicator of UHI but it much easier to measure (satellite remote sensing gives 80m resolution)
- **Ordinary Least Squares Assumption Violation**
 - No geographic component to the model
 - Mitigated the effects of this violation with sparse sampling, but there is still spatial autocorrelation of residuals

REFERENCES

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