Analysis of Airport Traffic Impact on Land Surface Temperature Variability through MODIS and Landsat Remote Sensing: A Case Study of Atlanta's Hartsfield-Jackson Airport

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Introduction

The Urban Heat Island Effect refers to the phenomenon where cities experience higher temperatures than their surrounding areas. This is due to urban surfaces, like asphalt and concrete, which absorb more sunlight, and also due to the lack of trees and green spaces.

Airports consist of tarmacs, runways, and parking lots, which are constructed from materials like asphalt and concrete. This allows airports to have a similar Heat Island effect as cities (Gough & Leung, 2022).

In 2020, a global pandemic caused by the coronavirus COVID-19 limited travel and forced many to stay indoors until the lockdown ended. Air travel was severely impacted, as there was a significant reduction in the number of operating aircraft (Garrow, 2020). We aim to evaluate whether the reduced air traffic and human activity in 2020 had a measurable impact on surface temperatures at the airport relative to the surrounding urban area.

Methodology

Research Area Selection

- The Atlanta area was selected because Hartsfield-Jackson is one of the busiest airports in the US. In addition, the airport is several kilometers from the city center, allowing for a distinct heat island from city heat, but close enough to share weather conditions.

MODIS (Terra + Aqua) and Landsat 8/9

- MODIS captures data every 1-2 days in a 1 sq km resolution. It's flown on NASA's Terra and Aqua satellites in sun-synchronous polar orbits.
- Landsat 8/9 captures data every 16 days in a 900 sq m resolution. Smaller temporal resolution makes it ideal for long term study.

Data collection

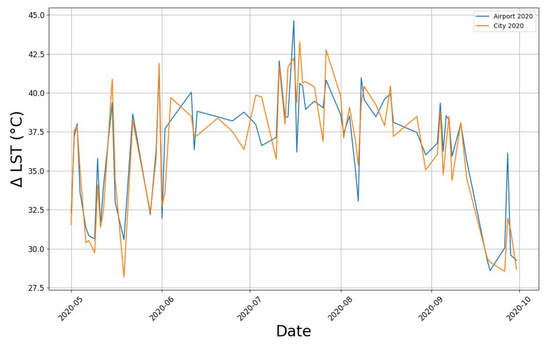
- Google Earth Engine to collect LST data from MODIS and Landsat within our locations of downtown Atlanta and Hartsfield-Jackson Airport. Data was collected from May 1st to October 1st of 2020 and 2024. The Terra and Aqua datasets supplemented many of the gaps in the data, as well as Landsat 8 and 9.

Data analysis

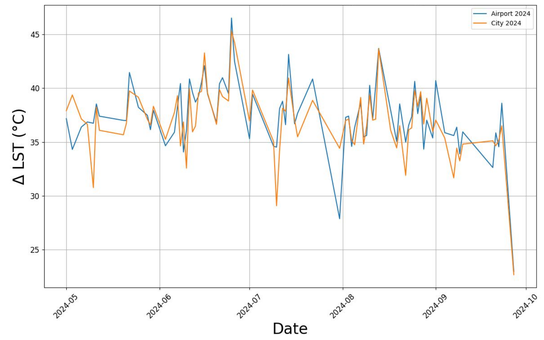
- The average LST in both the city and the airport for a given day was calculated using MODIS LST data, averaged across available cells within the study area. Graphs were generated with Python with the matplotlib library, while the Landsat visualizations were created with Google Earth Engine.

Results

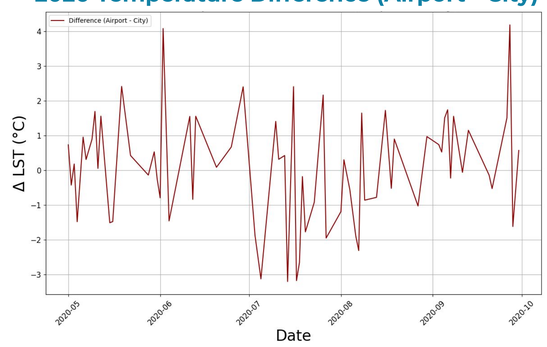
2020 Daily Average LST



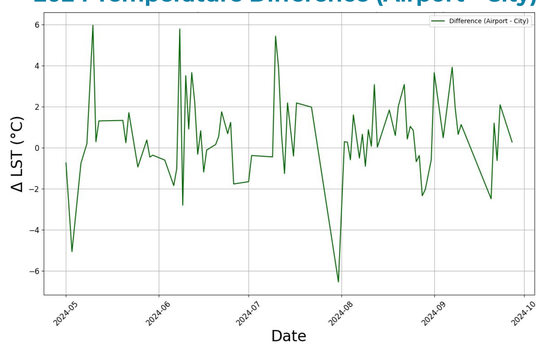
2024 Daily Average LST



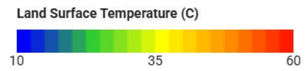
2020 Temperature Difference (Airport - City)



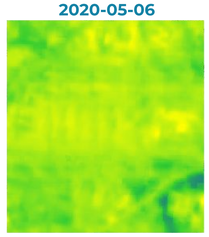
2024 Temperature Difference (Airport - City)



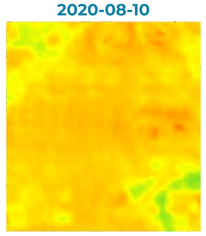
Selected Landsat Images at Hartsfield-Jackson Airport



2020-05-06

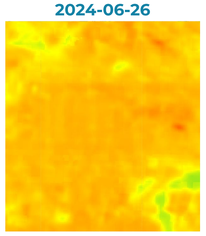


2020-08-10



2024-05-01

2024-06-26



Due to cloud cover, many Landsat visualizations of the target area have been obscured, as well as the image for 2024-05-01 is incomplete.

Independent sample t-test
Daily average temperature difference (airport - city) in 2020 and 2024

t statistic	p (One-tailed)	df	Mean Difference	Std. Error Difference
1.40996	.08037	142.58327	.42733	.48560

Discussion

2020 LST graph was derived by averaging 2533 temperature measurements, while 2024 used 3179 temperature measurements.

The temperature difference graphs were determined through subtracting the daily average airport temperatures from city temperatures.

A t-test comparing the daily average temperature differences between 2020 and 2024 yielded a p-value of 0.08, as shown in the table. This indicates a marginally significant difference.

This suggests that in 2024, the city-airport temperature gap tended to be larger than in 2020.

Conclusion

Our data suggests the airport's surface temperature has increased post-COVID relative to the downtown Atlanta city center. Airport traffic appears to contribute large amounts of heat to the land surface temperature of the airport. This may be due to the increase of airport activity post-COVID.

One limitation we faced is that cloud cover may produce invalid surface temperature data. Many images from Landsat had extensive cloud cover, which rendered many measurements unreliable. In addition, MODIS data does not take into account clouds or cloud shadows. This typically has a minimal effect due to the 1 km by 1 km spatial resolution, but it may have an impact on average surface temperature data on days with extensive cloud coverage.

Future research can expand this study into other cities, where the changes in airport LST during and post-COVID can be compared across multiple sites.

References

[1] Garrow, L. A. (2020, August–September). *The first 100 days: How airlines responded to the COVID-19 crisis. Avionics International.* Retrieved from https://interactive.aviationtoday.com/avionicsmagazine/august-september-2020/the-first-100-days-how-airlines-responded-to-the-covid-19-crisis/

[2] Gough, W. A., & Leung, A. C.-W. (2022). Do airports have their own climate? *Meteorology*, 1(2), 171–182.

[3] Smith, J., Doe, J., & Jones, P. (2022, December). *The aviation heat island effect: A novel investigation into the contributions of airports to the urban heat island effect (UHIE) and how their effects can be mitigated* Abstract presented at the AGU Fall Meeting.