The Impacts of Different Building Materials on Nearby Temperatures during the Summer Season in Raleigh, North Carolina

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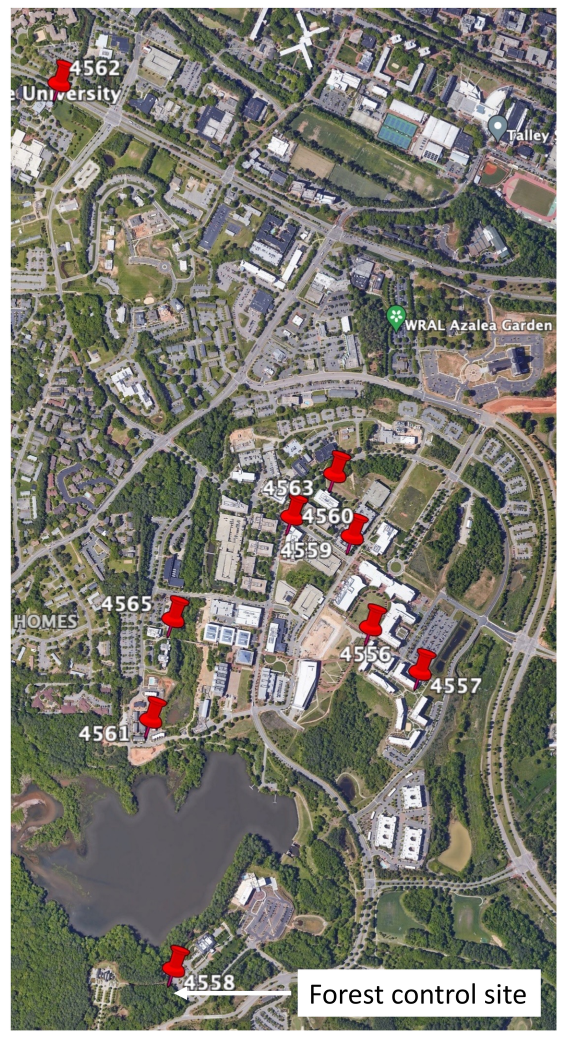
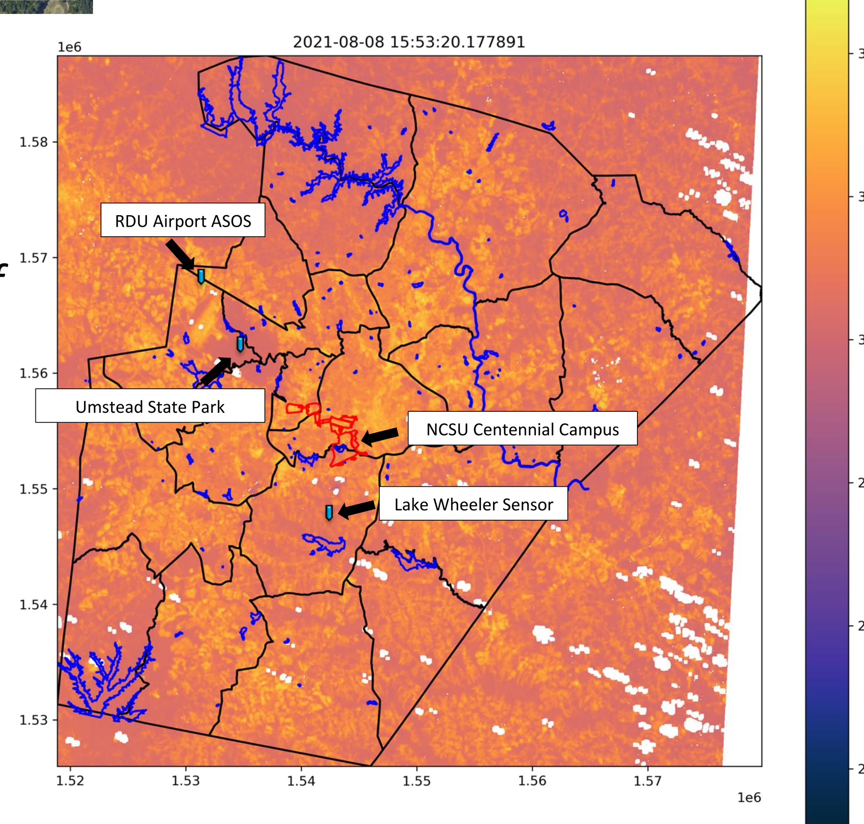


Introduction

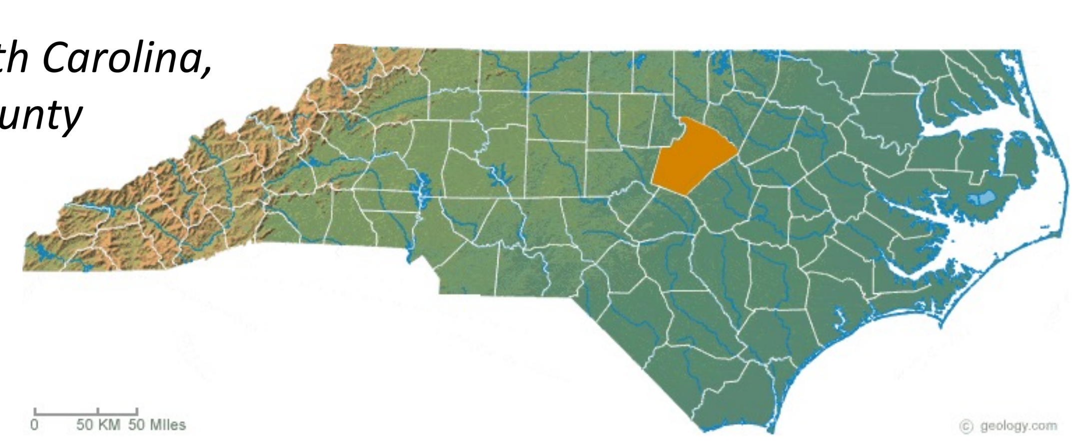
Wet bulb temperature is a measure of heat stress (Fox et al. 2014). For people working outside, higher wet bulb temperatures necessitate higher water intakes and longer rest periods. This project aims to identify how different building exteriors change the wet bulb temperature next to the building as compared to a control site in a nearby forested patch on campus.



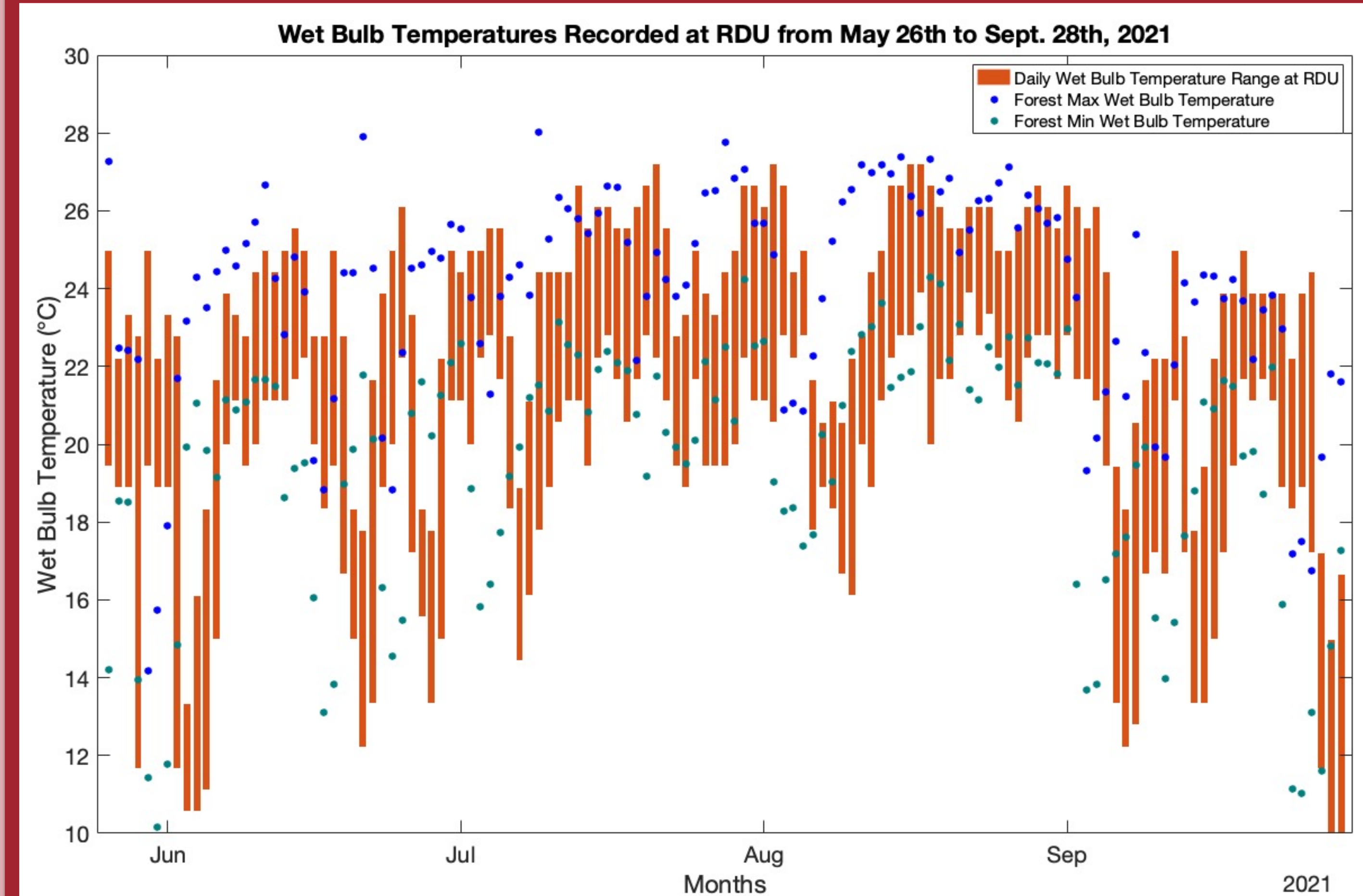
Above: *Closeup map of campus sensor locations.*
Right: *Regional map of surface temperatures in Wake County on August 8, 2021 highlights spatial temperature patterns in more urban versus more rural and forested locations.*

Data and Methods

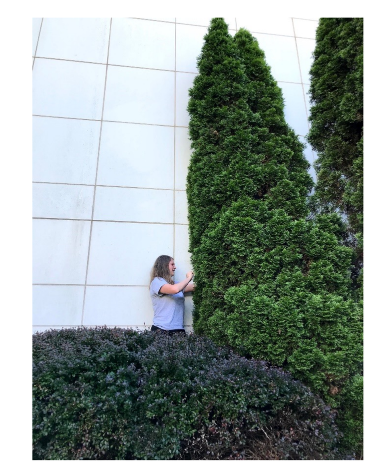
Nine Onset HOBO MX2301 temperature and relative humidity sensors were placed in areas around North Carolina State University's Centennial Campus. One sensor was placed in a forested patch as a control. The rest were placed by walls of different building exterior materials. All sensors were in bushes to reduce the direct solar radiation. Data were recorded every 5 minutes. The station pressure data at the Lake Wheeler NC ECONet site was used as part of the input to calculate wet bulb temperature from the HOBO sensors.

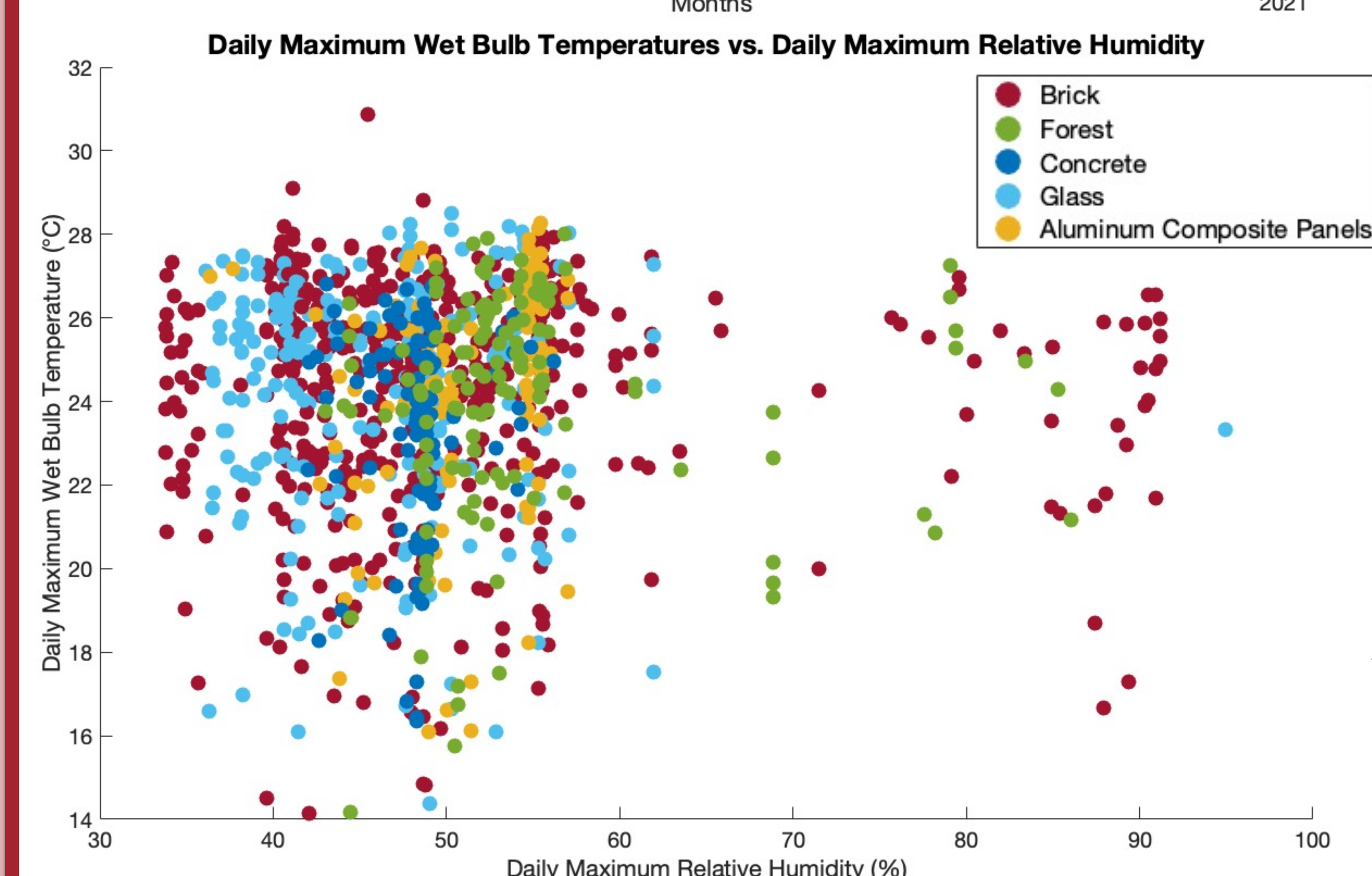


A map of North Carolina, with Wake County highlighted in orange.

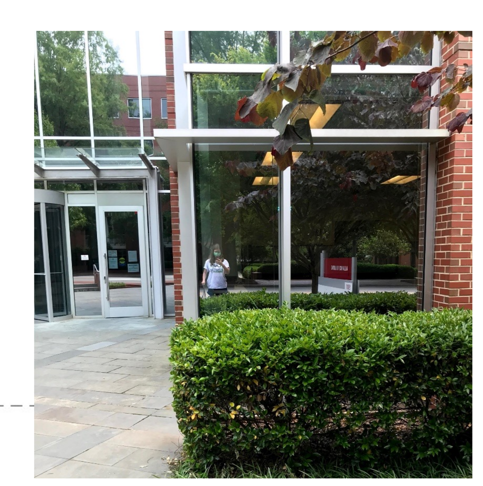


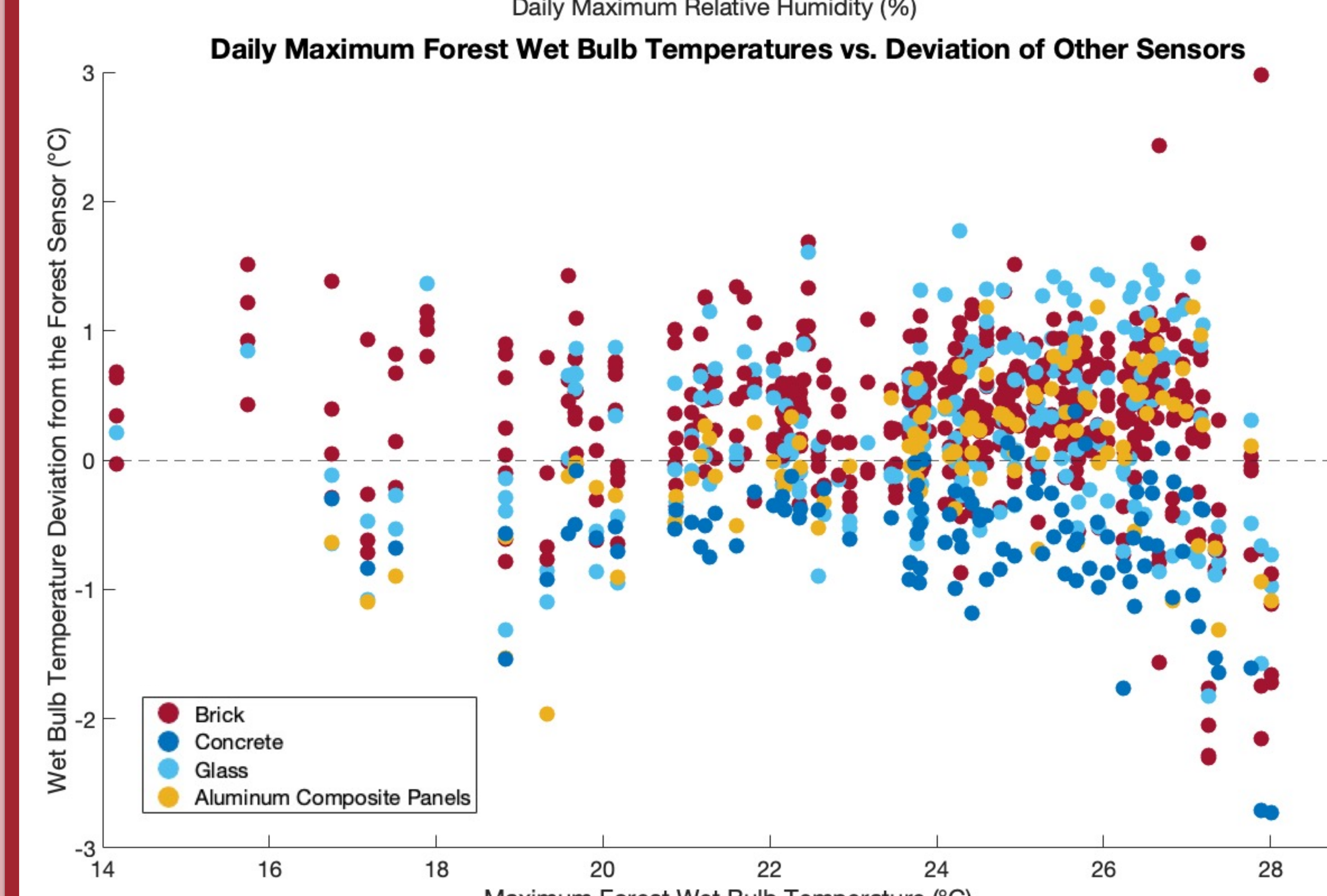
Left: *Daily wet bulb temperature range recorded at RDU ASOS with the maximum and minimum wet bulb temperatures for the forest control.* ***Below:*** *Aluminium Composite Panels that a sensor was placed by.*





Left: *Daily maximum wet bulb temperatures in relation to the relative humidities recorded at the same time.* ***Below:*** *An example of the glass exterior a sensor was placed by.*

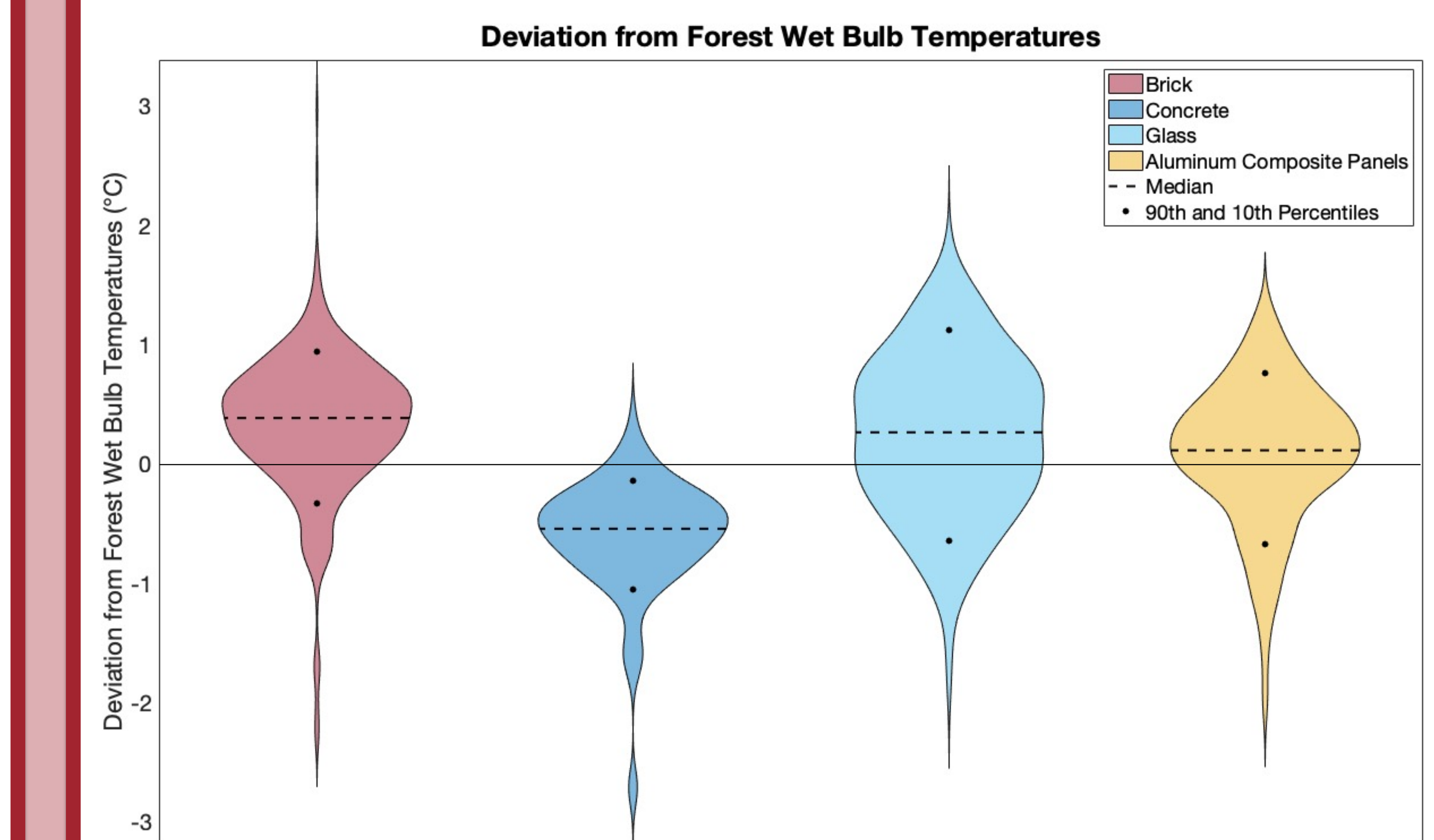




Above: *The deviation in maximum wet bulbs temperatures for each building material with respect to the daily maximum forest wet bulb temperature.*

Table 1: *how many sensors are allocated to each building exterior material.*

Material	Number of Sensors
Brick	4
Forest	1
Concrete	1
Glass	2
Aluminum Composite Panel	1



Distributions of the deviations of daily max wet bulb temperatures from the daily max forest wet bulb temperature for each exterior type.

Table 2: *Building exterior material characteristics relevant to nearby wet bulb temperatures.*

Material	Heat Capacity (J kg^{-1} K^{-1})	Emissivity Constants	Albedo
Brick[3,7]	900	0.93	0.30
Concrete[3,8]	960	0.85	0.40
Glass[2,3,7]	840	$0.02 < \varepsilon < 0.84$	0.31
Aluminum Composite Panel (ACP)[1,4,5,6]	900	0.81	0.61

Summary

- The range of wet bulb temperatures reported at RDU airport is from about 10°C (50°F) to about 27°C (80.6°F), similar to the range found in the campus forested patch. Relative humidities associated with the daily max wet bulb temperature were usually lower than 60%.
- There is no clear association between the daily maximum forest wet bulb temperature and the deviations of other sensors' wet bulb temperatures
- Concrete exteriors usually have a slightly cooler wet bulb temperature deviation relative to the forest as compared to other building materials. This implies that there is less heat stress for people and plants in areas surrounding concrete buildings compared to brick, glass, and aluminum composite exteriors.

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References: [1]Piedra et al. (2019) Aerospace,; [2]BDC Univ. (2018) Vitro Architectural Glass.; [3]Engineering Toolbox (2019) Specific Heat of Solids, Emissivity Coefficients Materials.; [4]Stacbond (2020) Aluminium Composite Panel.; [5]MatWeb (2022) Online Materials Information Resource.; Fox et al. (2014) Fermentation and Biochemical Engineering Handbook (Third Edition).; [6]Kynar (2012) Reflect-Tec Heat Reflective Roof Coating.; [7]Bradley et al. (2002) Modeling Spatial and Temporal Road Thermal Climatology in Rural and Urban Areas Using a GIS.; [8]Global Cement and Concrete Association (2022) Albedo. **Acknowledgements**: ECONET data from the NC State Climate Office. Special thanks to Ronak Patel and Laura Kent for their help in determining sensor placement, Luke Allen for permission to use his surface temperature map for this poster, and Landon Baity for his eye for design.