Quantifying the Dependencies of Rooftop Temperatures on Albedo

Anthony Dominguez, Jan Kleissl, UC San Diego
Jeff Luvall, NASA MSFC

Presentation Overview

- Project motivation
- DEMROES project background
- Research to date
- Future field studies
- Conclusion

Project Motivation

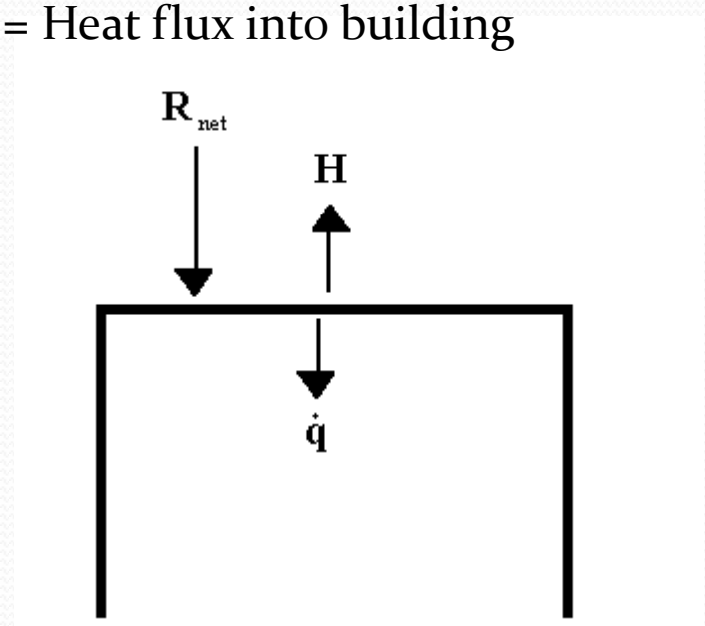
- The thermal properties of building materials directly effect the conditions inside of buildings
- Heat transfer is not a primary design driver in building design
- Rooftop modifications lower heat transfer, which lowers energy consumption and costs
- The 'living environmental laboratory' attitude at UCSD makes it the perfect place to test the success of these modifications.

Equations

R_{net} = net down-welling radiation

H = Sensible heat flux

q = Heat flux into building



$$R = \varepsilon \sigma T^4$$

$$R_{net} = (1-\alpha)R_{sd} - R_{lu} + R_{ld}$$

$$H = \rho c_p \left(\overline{w'\Theta'}\right)_s$$

$$H \approx -\rho c_p C_H \overline{M} (T_{air} - T_{roof})$$

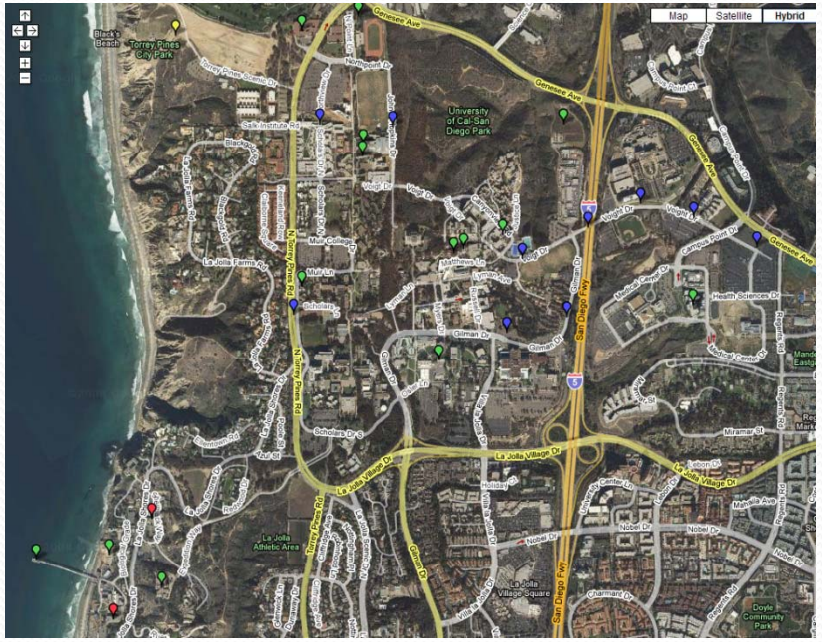
$$\dot{q} = k \frac{\left(T_{roof} - T_{ceiling}\right)}{dy}$$

Types of Rooftop Modifications

- High albedo (α) coatings
- Photovoltaic (PV) arrays

DEMROES Project Background

- DEMROES is a wireless network of real time meteorological stations installed across the UCSD campus



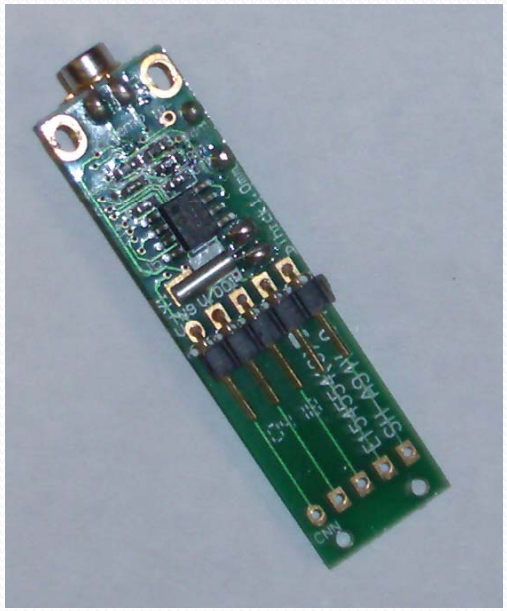
DEMROES- station overview

* Air temperature and humidity
* wind speed and direction
  rain
* Solar radiation (mean and variance)
* Solar panel temperature, power output
* Roof surface temperature

future: particulate matter

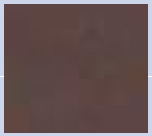
DEMROES- other sensors

Zytemp TN9 IR Sensor

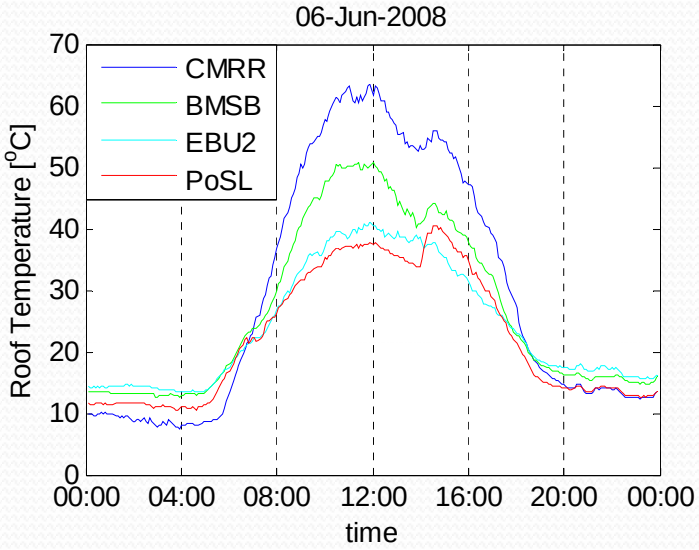


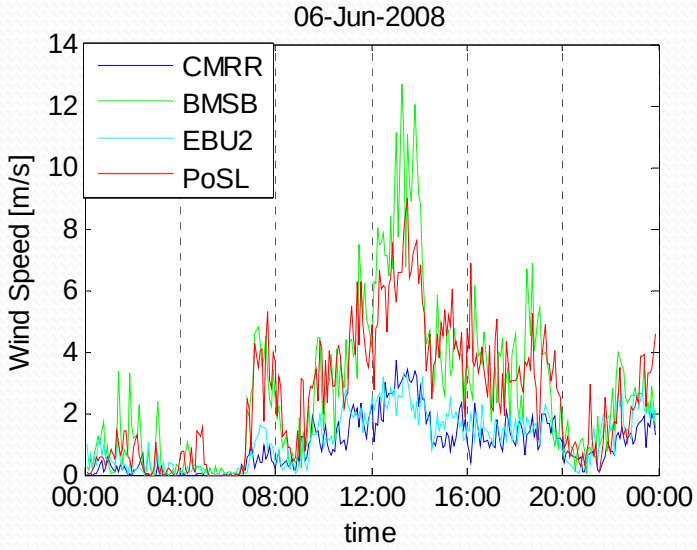
FLIR Thermovision A320

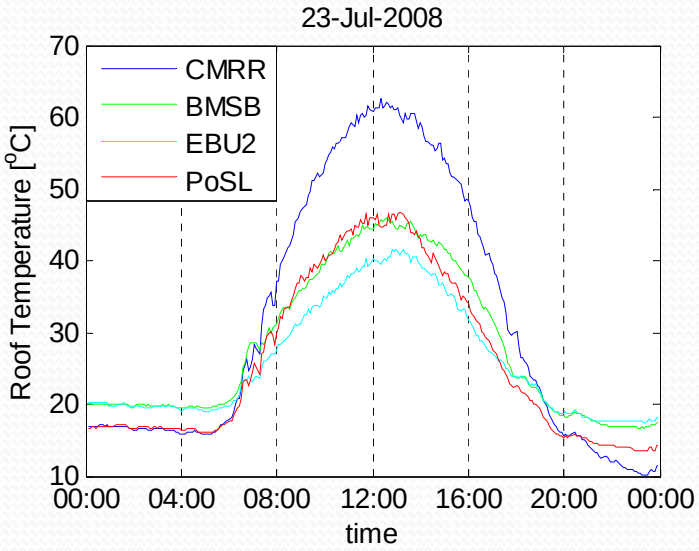
Results: Rooftop Properties

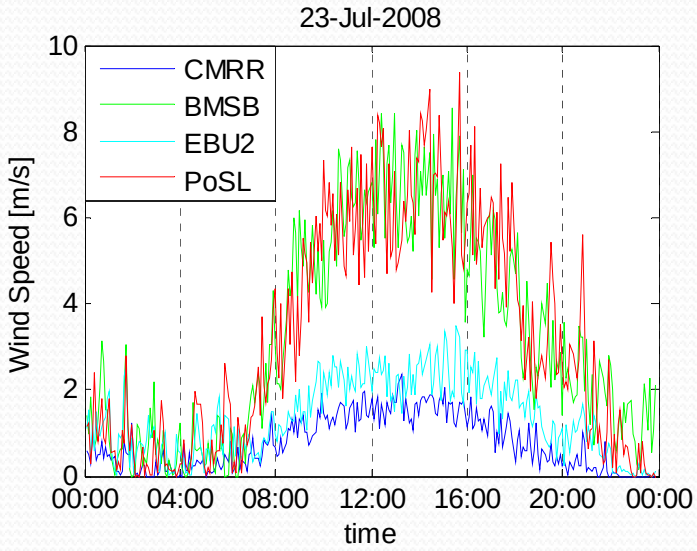
Building	Albedo	Roof Image
Center for Magnetic Recording Research (CMRR)	0.114	
Biomedical Sciences Building (BMSB)	0.187	
Powell Structures Laboratory (PoSL)	0.218	
Engineering Building Unit 2 (EBU2)	0.354	

Results: Typical Sunny Day Curves

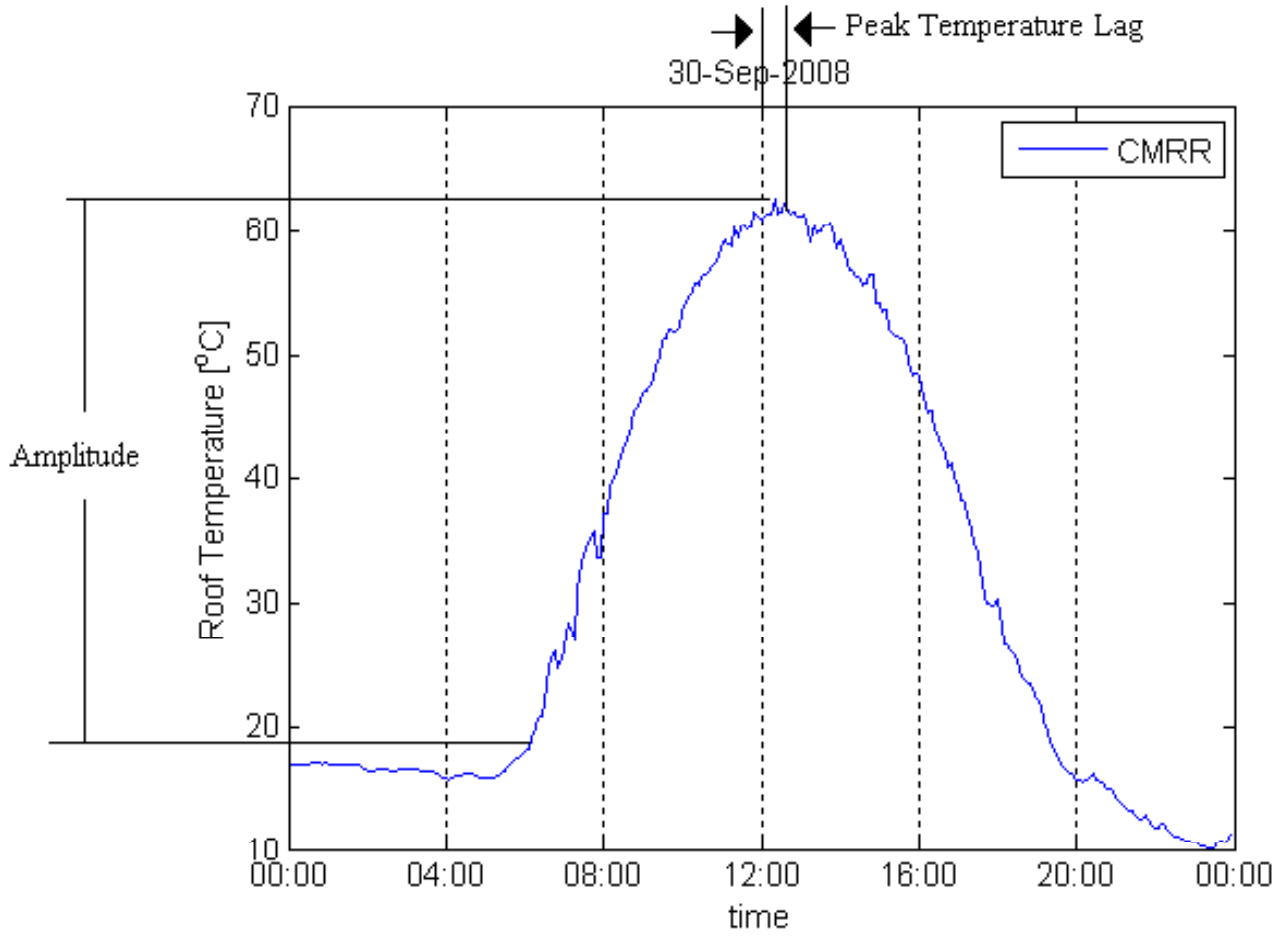




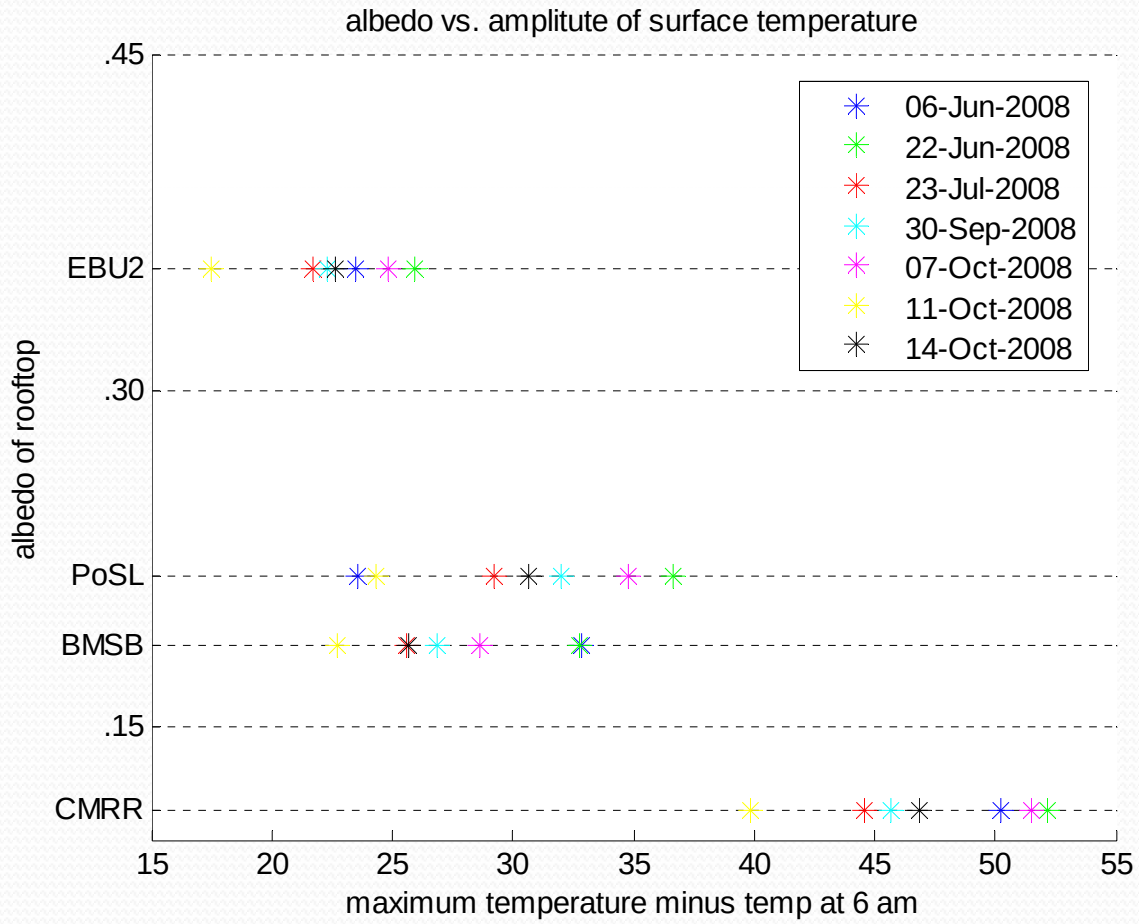




Results: Curve Characteristics



Research to Date – DEMROES data



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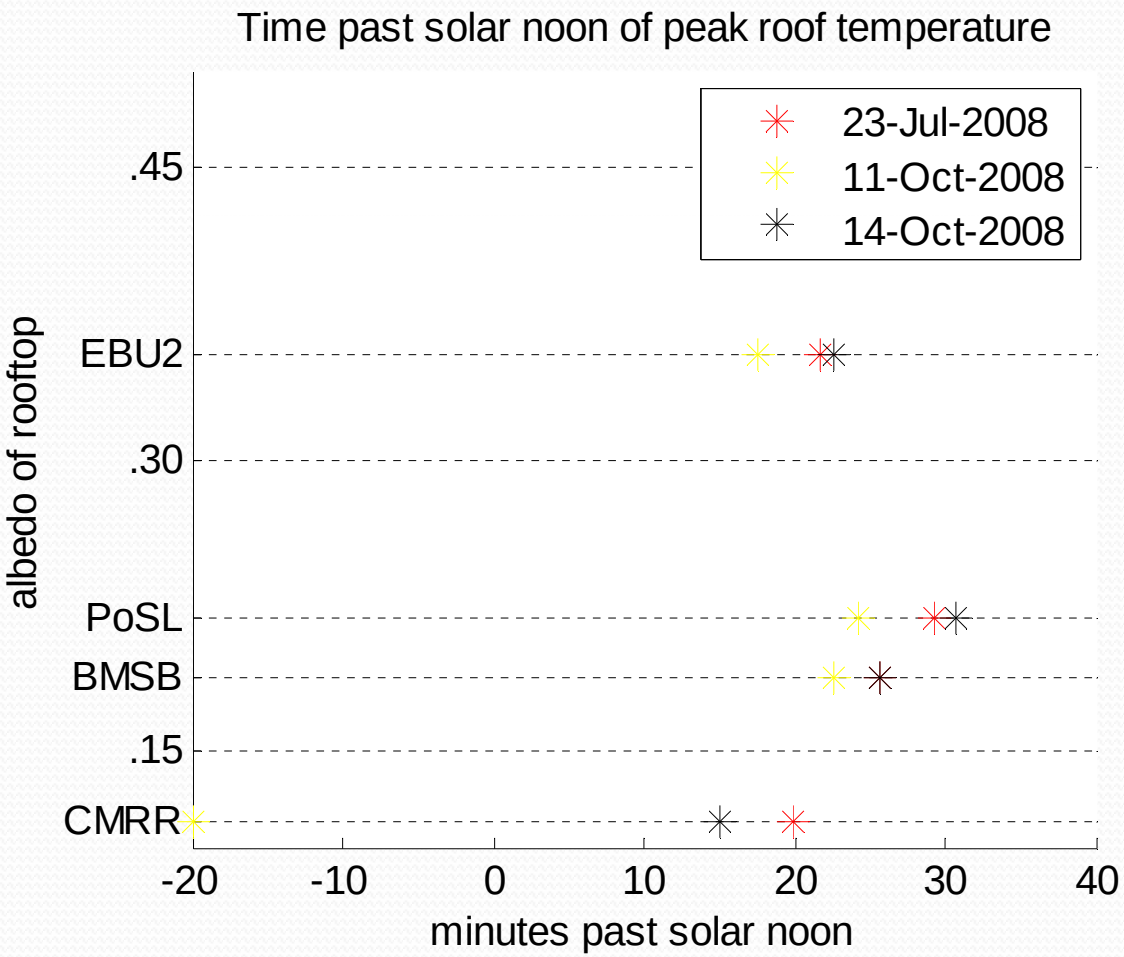
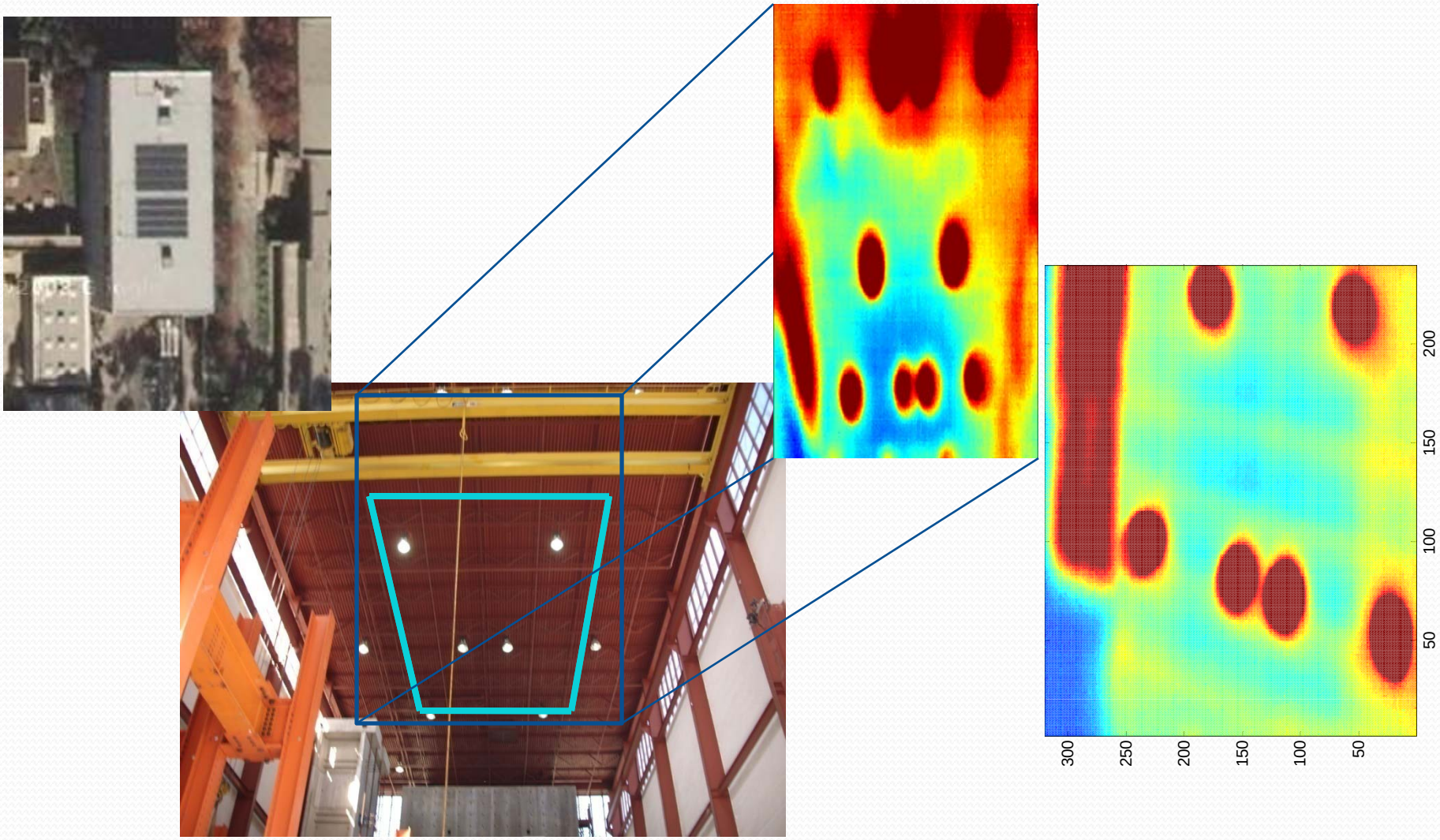


Future Analysis – Thermal camera imagery



Conclusions

- Higher albedo rooftops have less heat transferred into the buildings and lower energy costs.
- Though PV arrays have higher albedo, their spacing from the rooftop results in shading that could also lower energy costs, possibly more than high albedo coatings.
- Data from field campaigns as well as the continuous data from DEMROES and satellite IR data provided by NASA will better quantify the benefits of rooftop modifications.

References

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- Akbari H, Rainer L. Measured Energy Savings from the Application of Reflective Roofs in 3 AT&T Regeneration Buildings.
- Stull, RB. An Introduction to Boundary Layer Meteorology. Kluwer Academic Publishers. 1988