

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

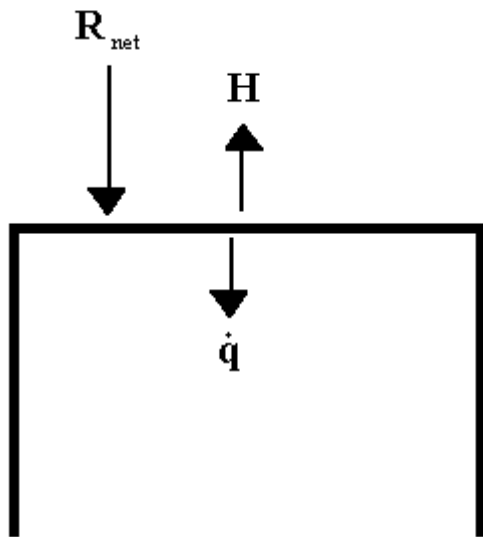
- The thermal properties of building materials directly effect the conditions inside of buildings
- Heat transfer is not a primary design driver in building design
- Rooftop modifications lower heat transfer, which lowers energy consumption and costs
- The ‘living environmental laboratory’ attitude at 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



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

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

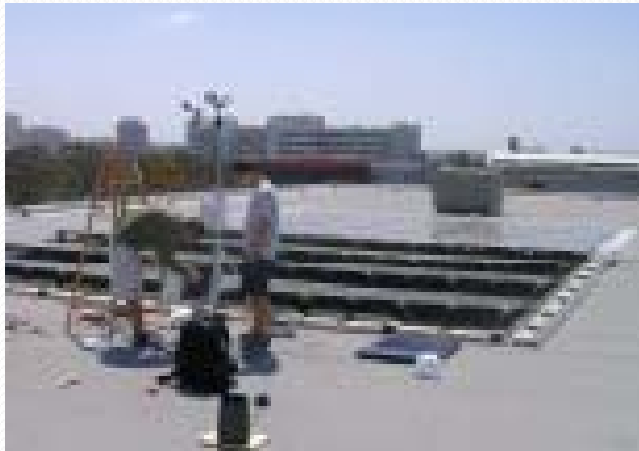
$$H = \rho c_p (\overline{w'\Theta'})_s$$

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

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

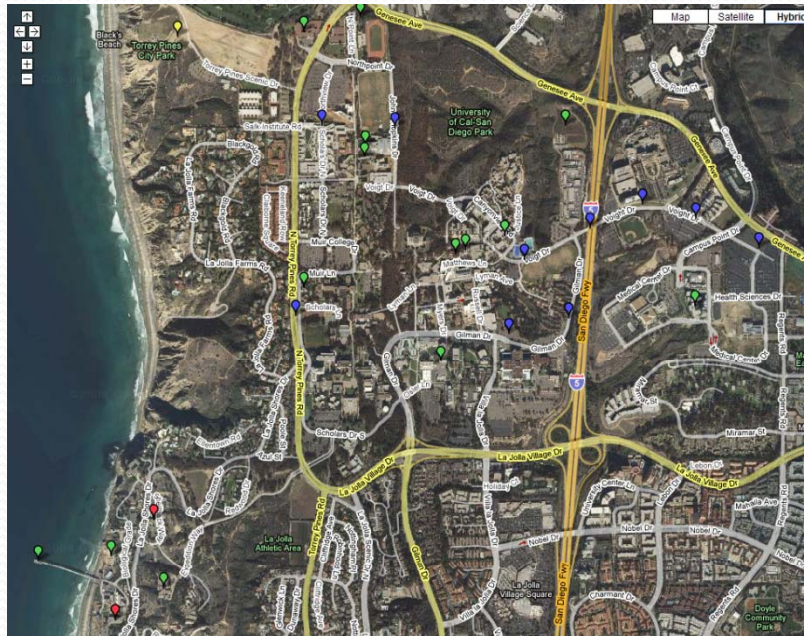
Types of Rooftop Modifications

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

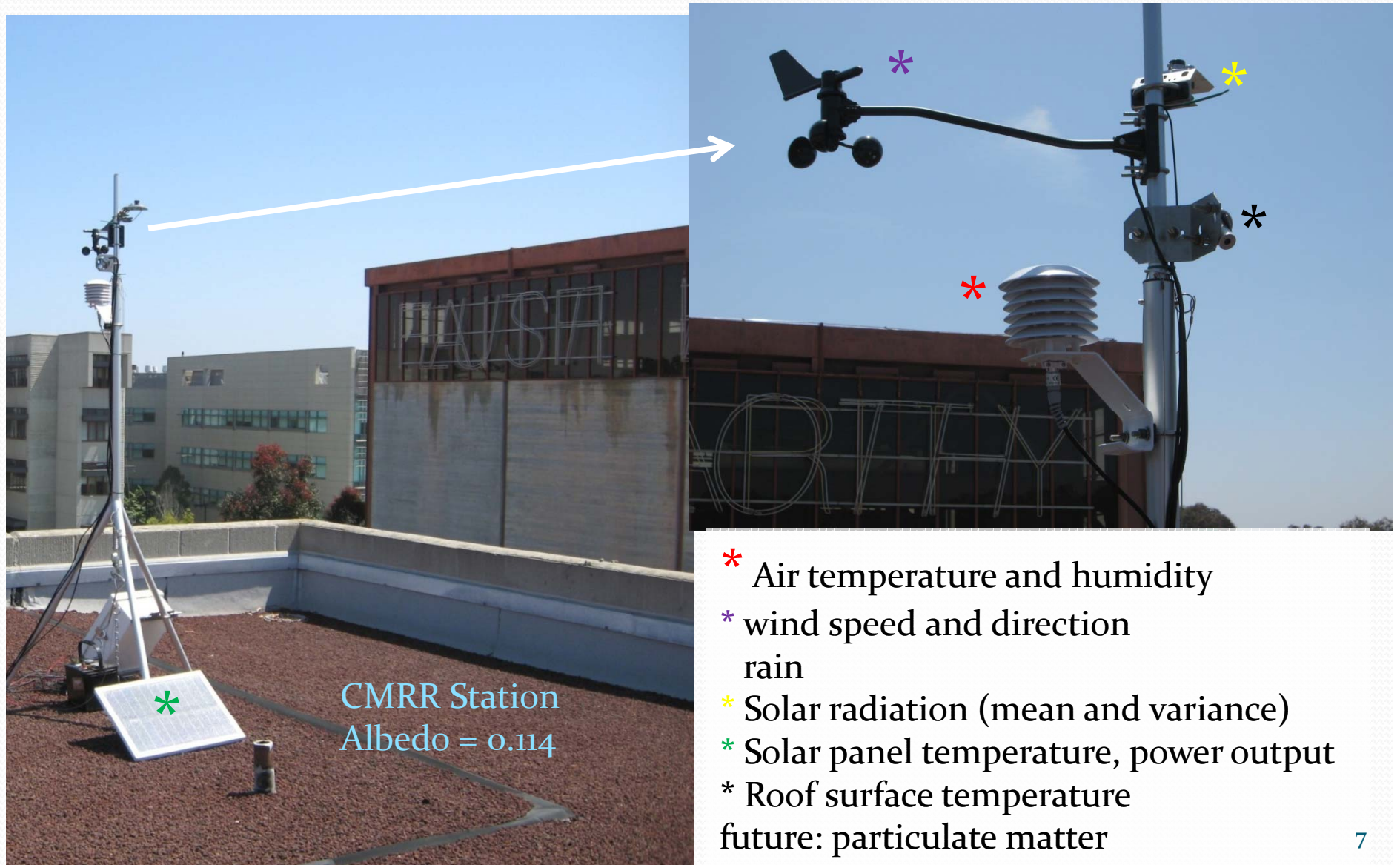


DEMROES Project Background

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

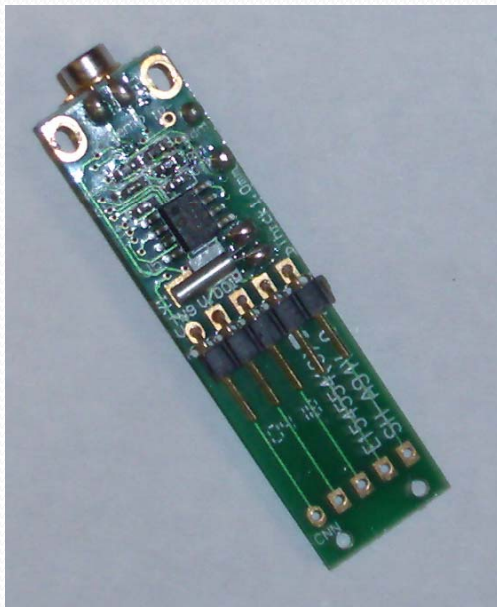


DEMROES- station overview



DEMROES- other sensors

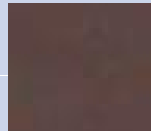
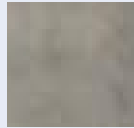
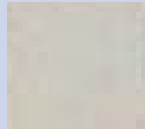
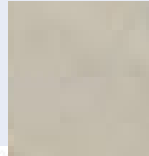
Zytemp TN9 IR Sensor



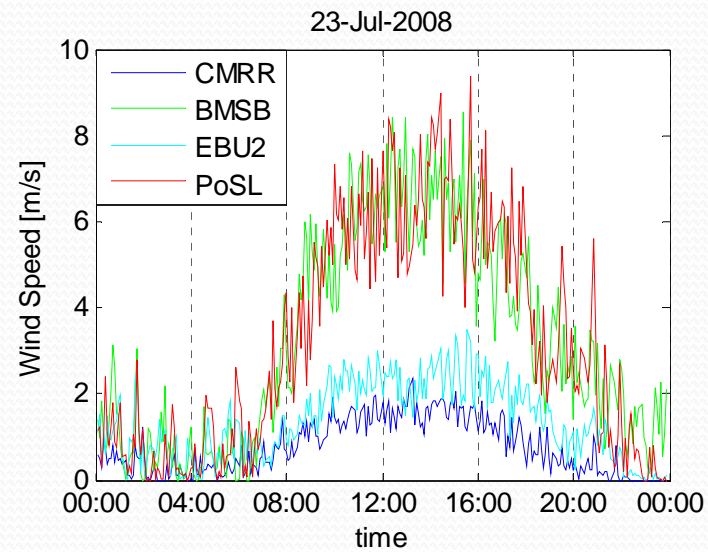
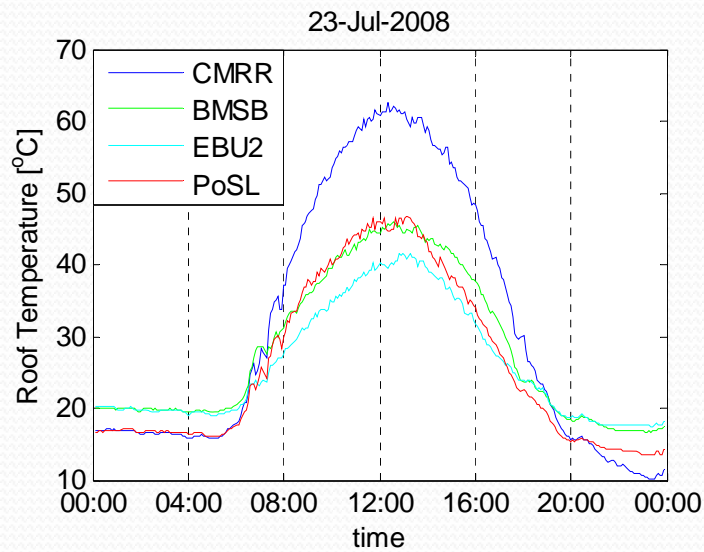
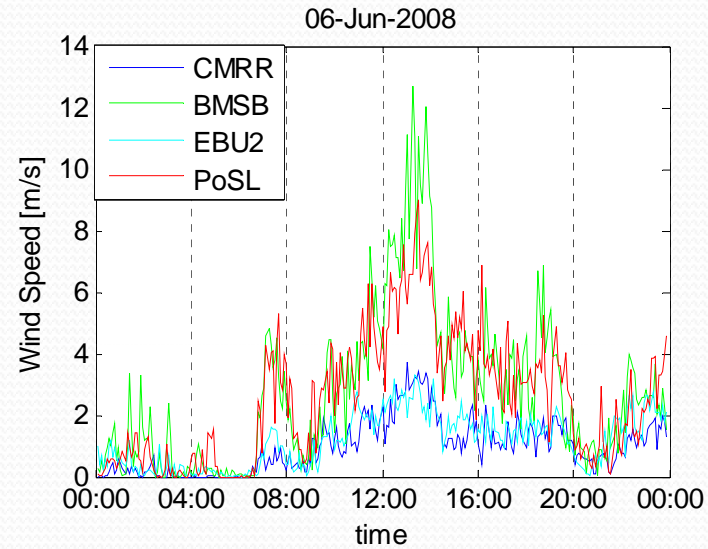
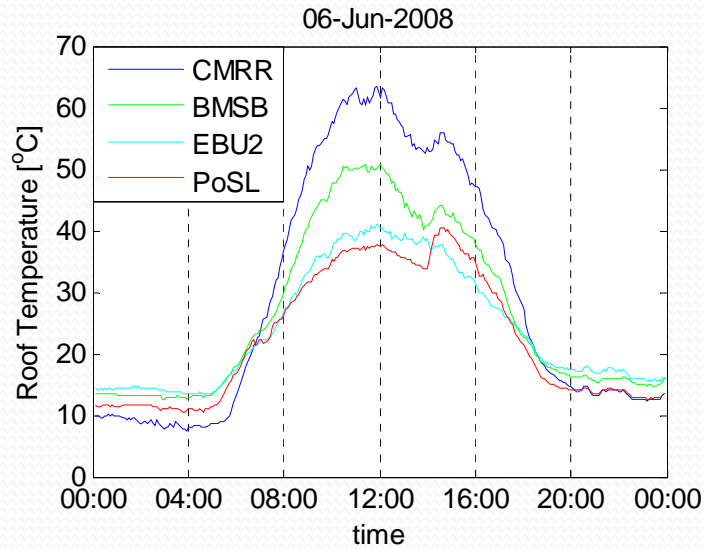
FLIR Thermovision A320



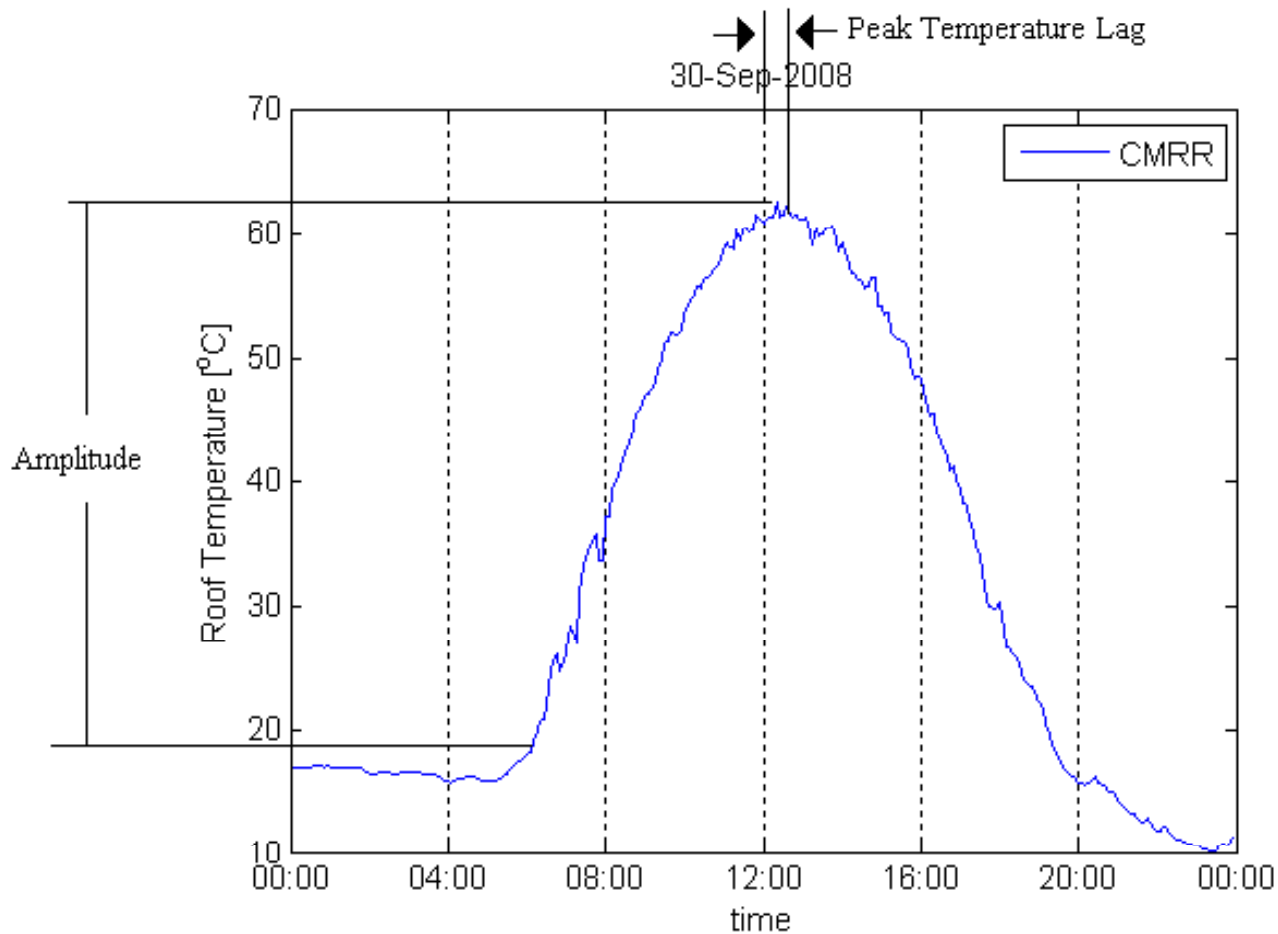
Results: Rooftop Properties

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	

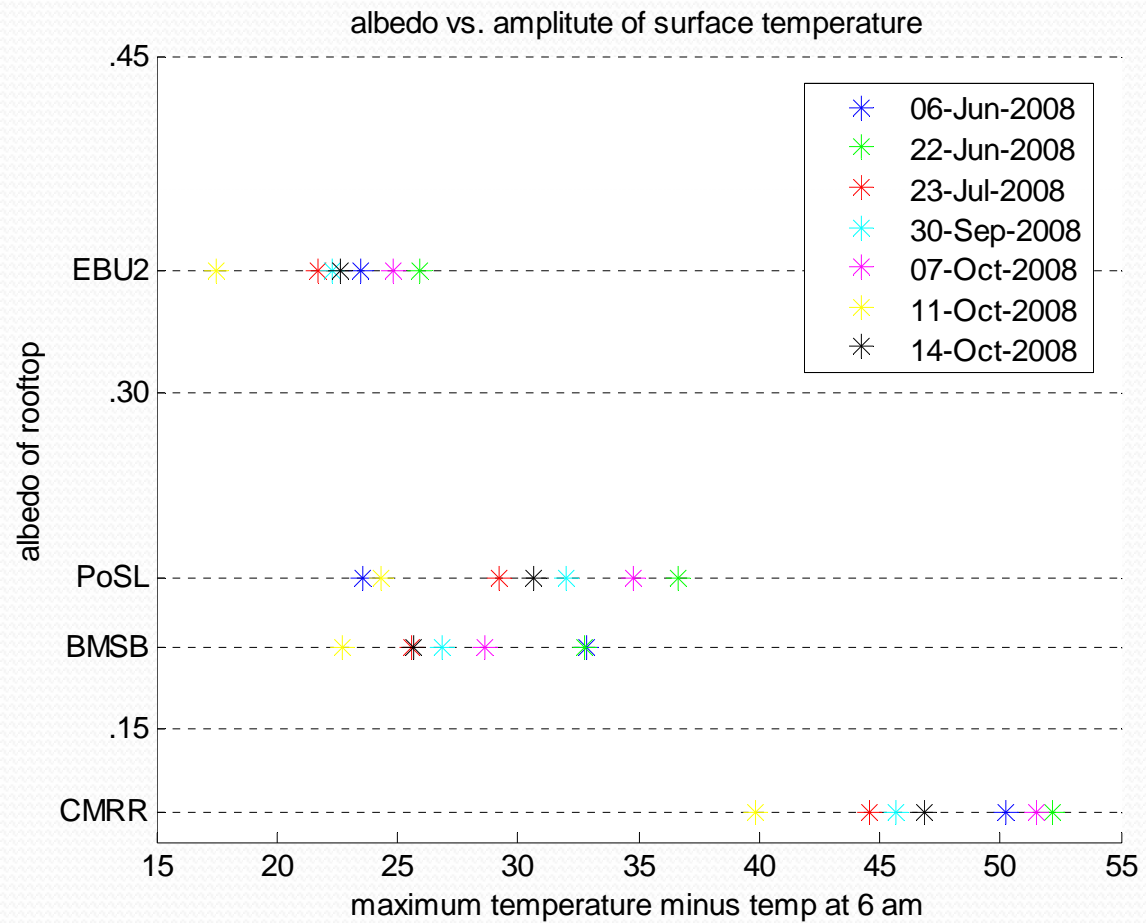
Results: Typical Sunny Day Curves



Results: Curve Characteristics

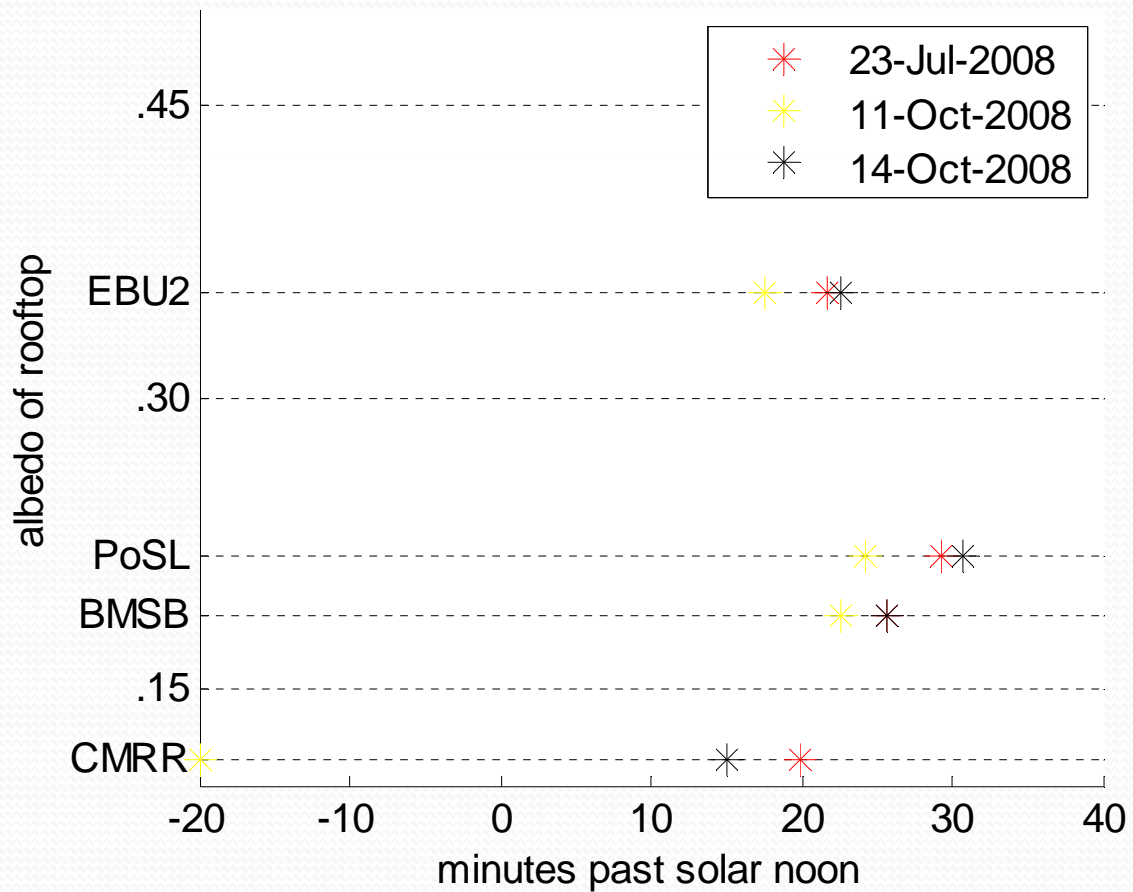


Research to Date – DEMROES data

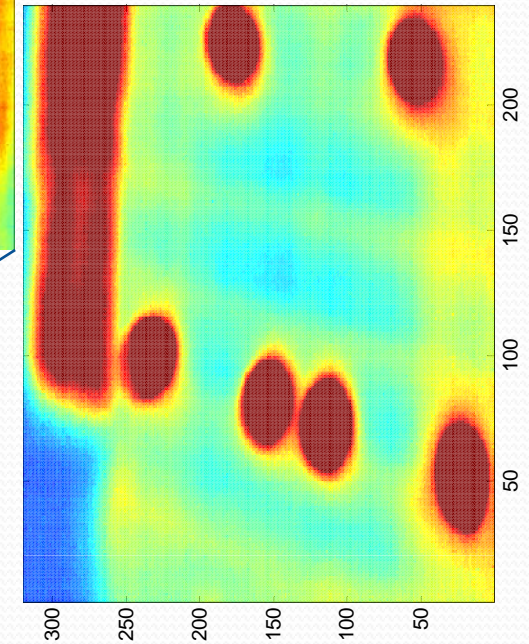
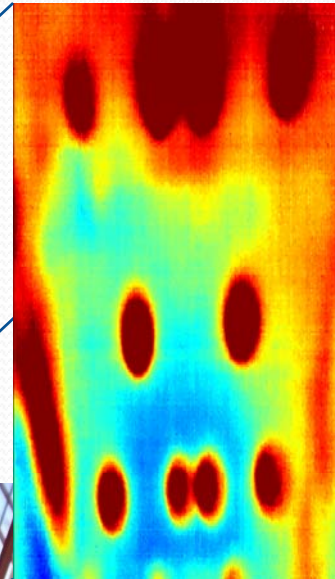


Research to Date – DEMROES data

Time past solar noon of peak roof temperature



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

- Akbari H, Gartland L, Konopacki S. Measured Energy Savings of Light-Colored Roofs: Results from Three California Demonstration Sites. 1998
- 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