PIER Research for the 2008 Residential Building Standards

UZM: a Residential ACM Attic/Duct Model

October 24, 2005

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Attic/Duct Model

- Attics with ducts are typical in California homes

- Energy efficiency depends on roof/attic/duct performance, particularly on peak

- An accurate model that evaluates all of the relevant measures in combination is needed for standards development

- An improved calculation that treats measures equitably is needed for performance compliance

Approach

- Learn from existing attic/duct models

- Develop proposed model in beta form

- Test and compare

- Integrate in special version of Micropas

- Support 2008 standards process

- Publish in 2008 ACM

Compliance Constraints

○ Include current measures and credits

○ Very limited field checkable inputs

○ The need to handle significant variations

- Crawl spaces with ducts

- Flat roofs with attics and ducts

- Multiple air conditioning systems

- Houses with multiple systems, multiple zones and ducts in attics, crawl spaces and indoors

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Efficiency Measures Covered

- Duct sealing
- Duct insulation (including buried ducts)
- Duct location (including conditioned space)
- Roof solar absorptivity and emmissivity
- Tile roofs
- Radiant barriers
- Attic ventilation
- Attic insulation
- Sealed attics
- Insulation construction quality

Limited Inputs

○ Roof type (gable or hip)

○ Pitch (4 in 12)

○ No other geometry or orientation

○ Vent details (free area and location)

○ Roof properties (solar absorptivity and infrared emmissivity, roofing type)

○ Current duct system inputs only

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Limitations

○ Generalized attic geometry

○ Simple hourly duct calculation adapted from current ACM duct model

○ Regression based attic infiltration and ventilation model

○ One attic space and one crawlspace per building

New Capabilities

○ Improved conditioned space air infiltration calculation

○ Unbalanced duct system leakage

○ Forced ventilation of attic using air from conditioned space

○ Radiant properties of duct surfaces

○ Impact of radiant barrier at gable ends

○ Impact of temperature on insulation R-value

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Results Check

- Compare to experimental data

- Compare to measured California data

- Compare to current seasonal duct calculation

- Compare to overall compliance results for prescriptive standards and important variants

Status

- UZM model complete

- Documentation draft complete

- Stand-alone UZM tested against data

- Micropas integration nearly complete

Flexible Roof Facility

Time of Day: June 16, 1997

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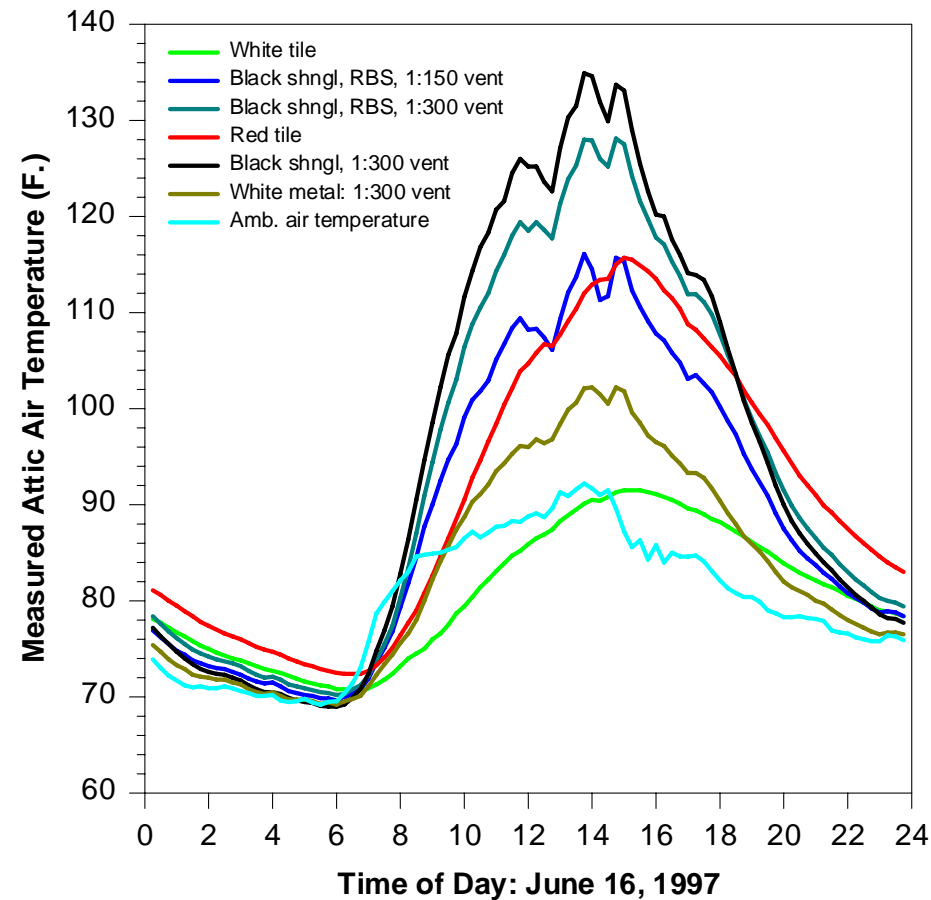
FRF Roof /Attic Testing

○ Roofs/Ventilation

○ Cool roofing systems

○ Measured heat flux

○ Attic air temperature

○ Weather conditions

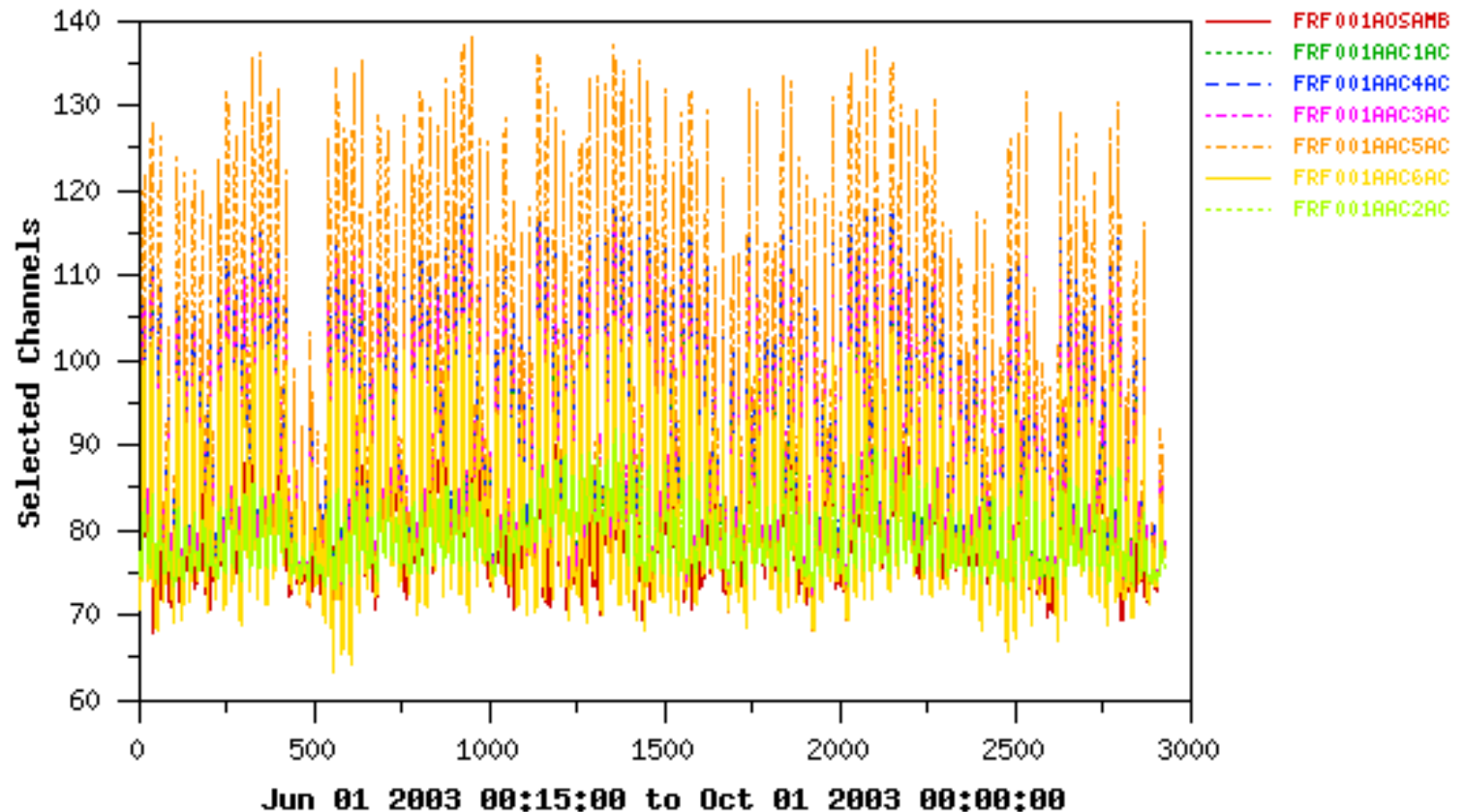○ Summer 2002-2003:
Unfinished vs.
Finished metal roofing
systems

FRF Testing 2003

- Metal Roofing long term exposure

  - Unfinished Galvanized

  - Unfinished Galvalume
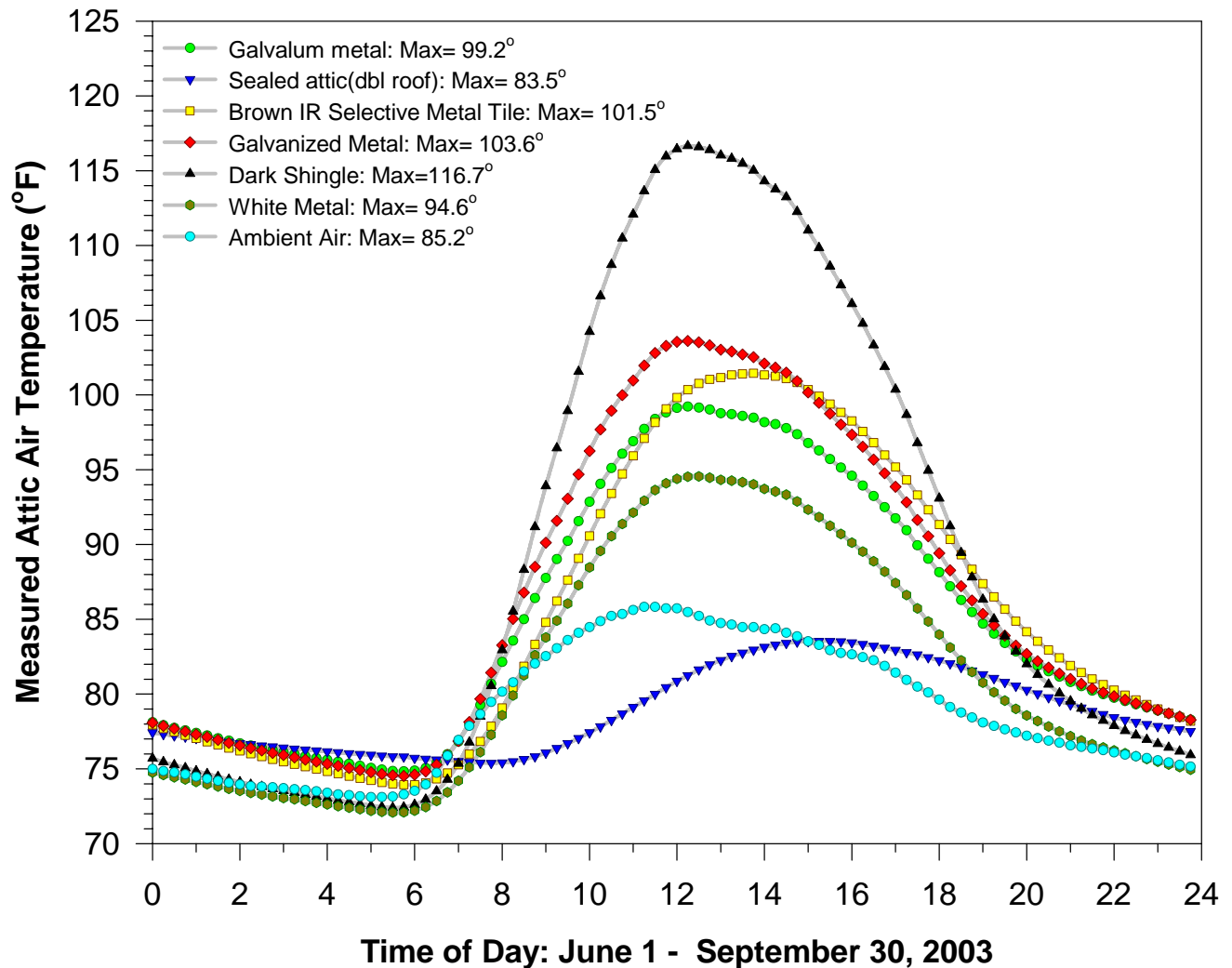
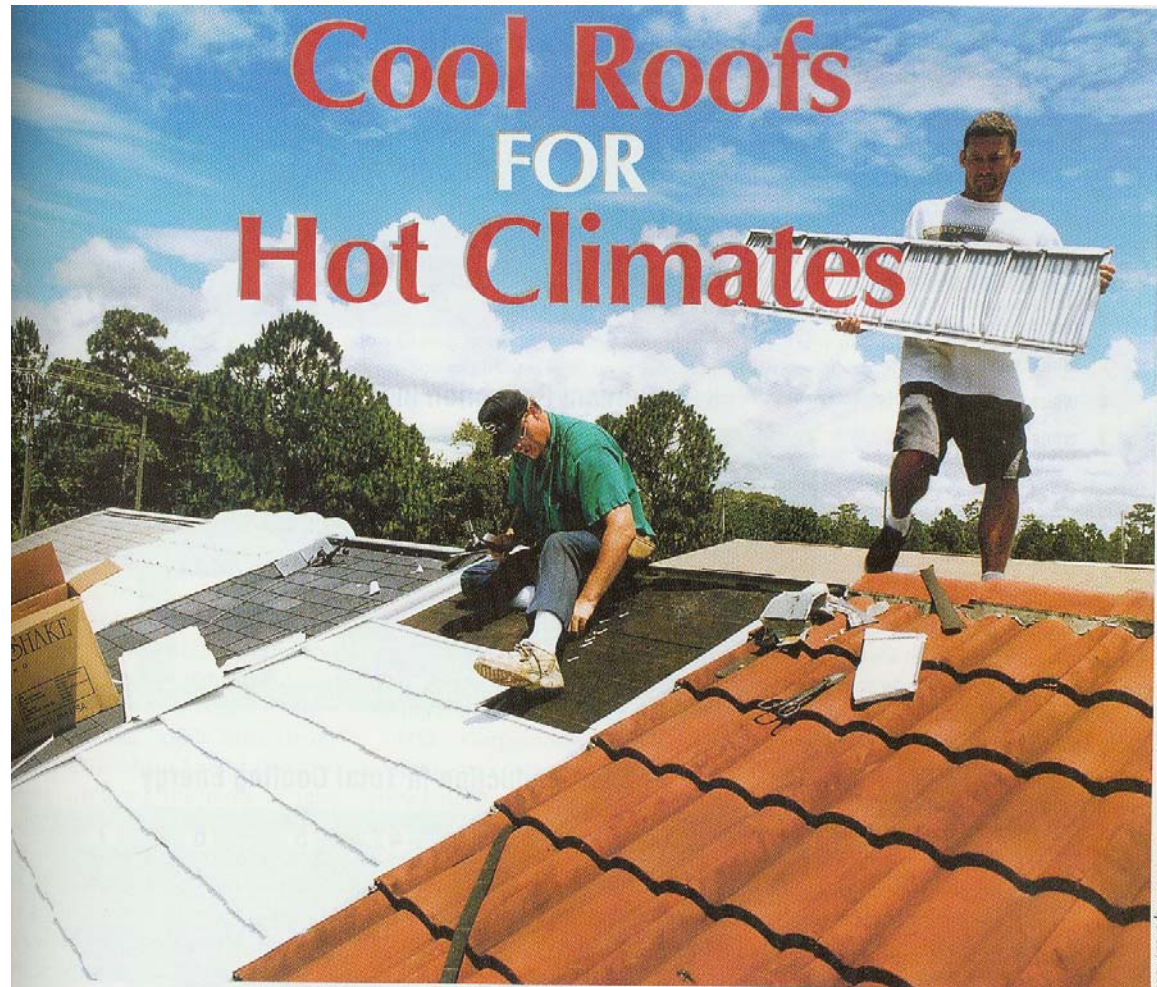 - IR Reflective Metal shingles

  - White metal roof

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Attic Temps over Summer

FRF Experiment Database

Average Temps Over Summer

Figure showing measured attic air temperature over time of day:

- Galvalum metal: Max= 99.2°
- Sealed attic(dbl roof): Max= 83.5°
- Brown IR Selective Metal Tile: Max= 101.5°
- Galvanized Metal: Max= 103.6°
- Dark Shingle: Max=116.7°
- White Metal: Max= 94.6°
- Ambient Air: Max= 85.2°

Y-axis: Measured Attic Air Temperature (°F)

X-axis: Time of Day: June 1 - September 30, 2003

Journal of Light Construction, *June 2003*

Cool Roofs FOR Hot Climates

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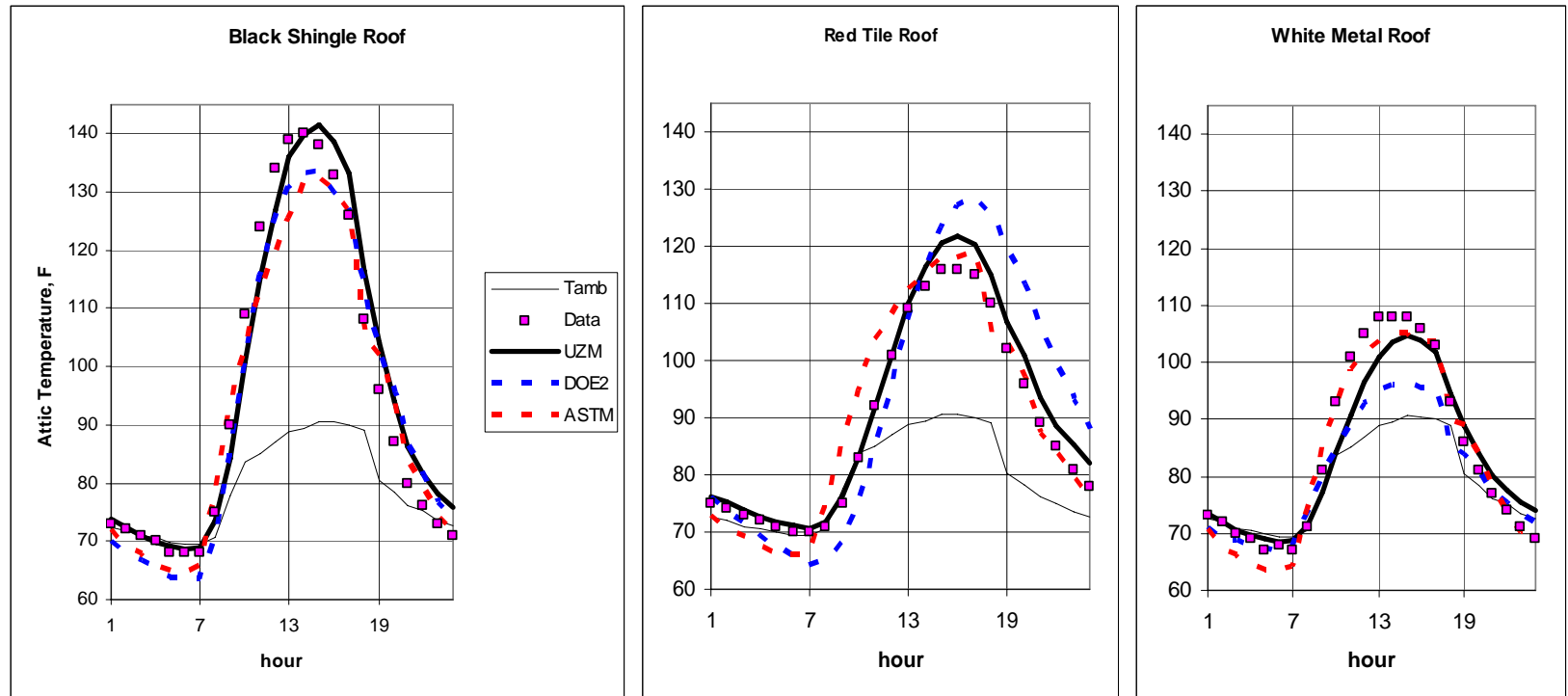
FRF July average attic temperatures
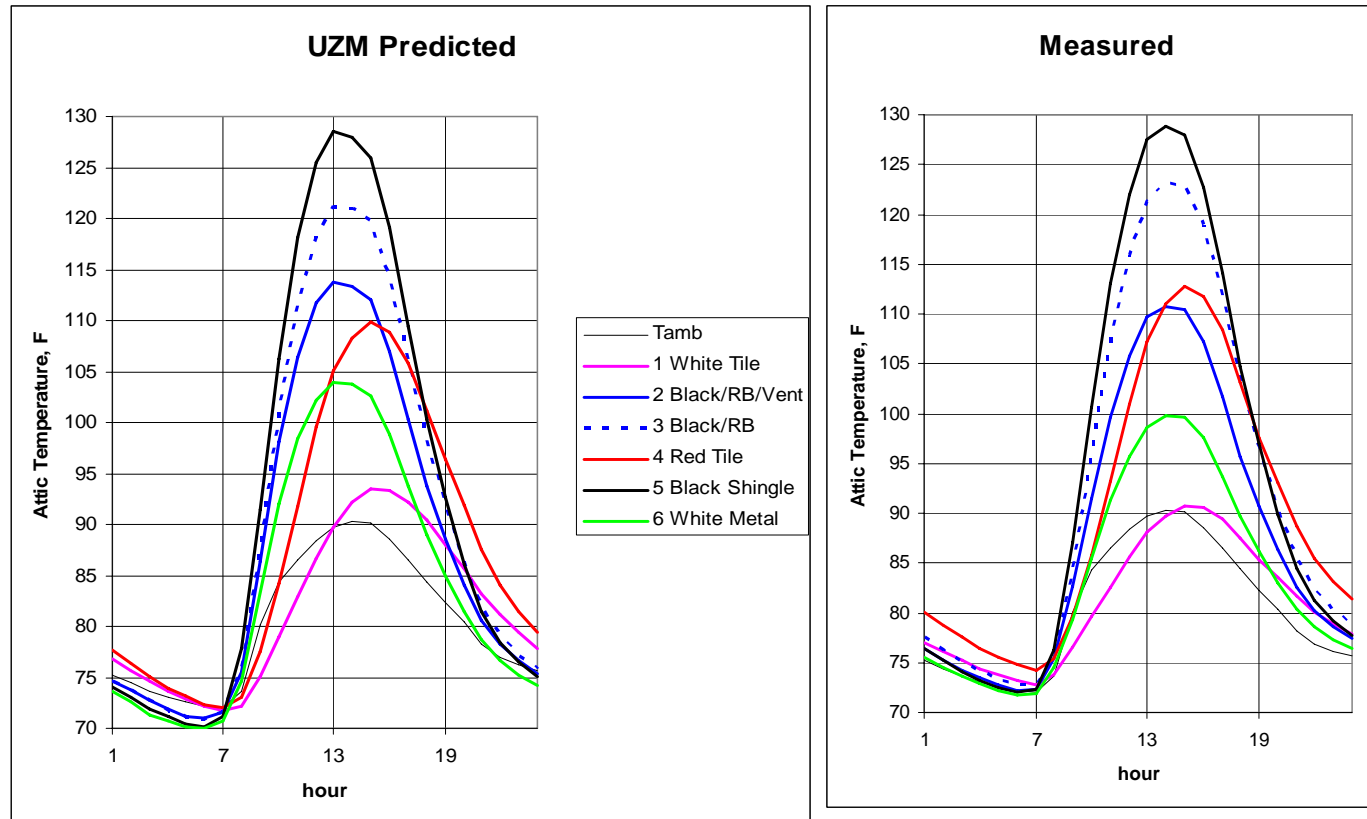
- UZM matches the relationship between roof type and attic temperatures for 6 different roof systems

FRF July peak attic temperatures
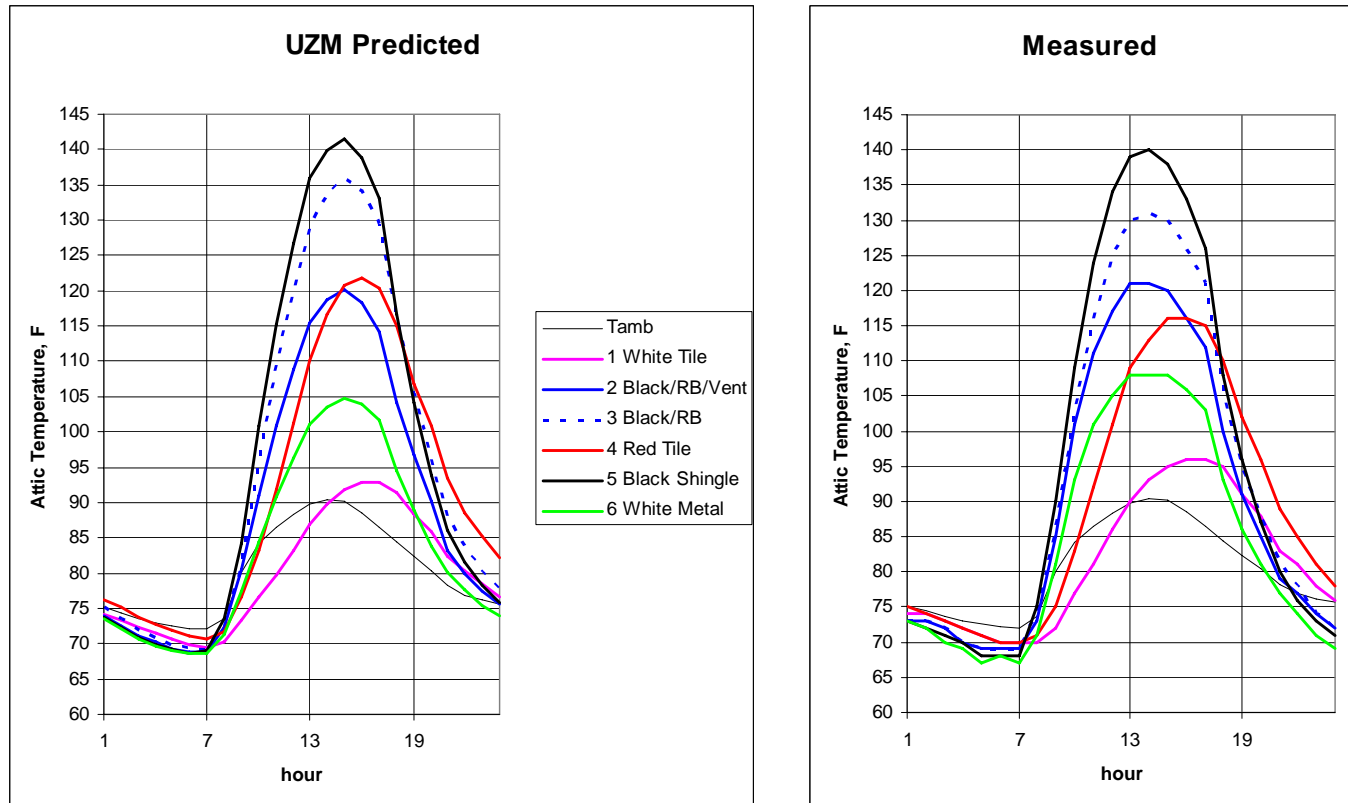
- UZM matches the measured data on peak day impacts of 6 different roof systems on attic temperatures

FRF July peak model comparison

- UZM matches the measured data on peak day temperatures as well as EnergyGaugeUSA or ASTM C-1340

California Data Comparison

- One year of measured attic temperature data for Cardinal Glass research house in Roseville

- Tile roof with high/low ventilation, sealed ducts in attic, ceiling construction defects, all modeled using proposed approach
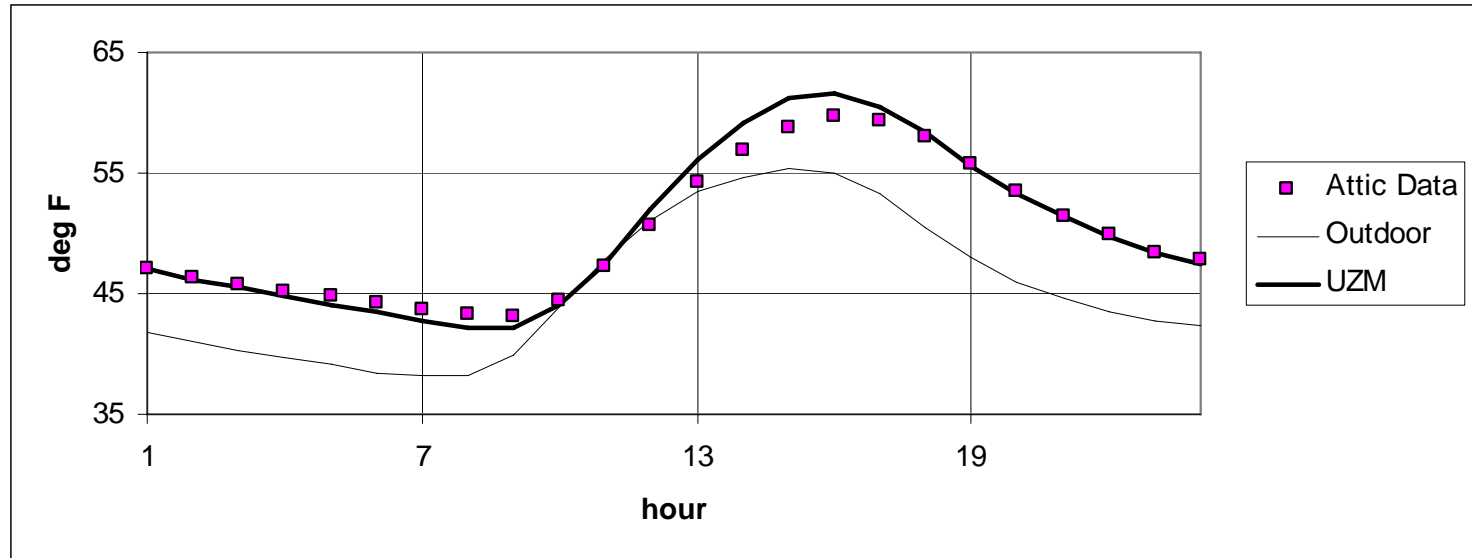
Daily attic temperatures
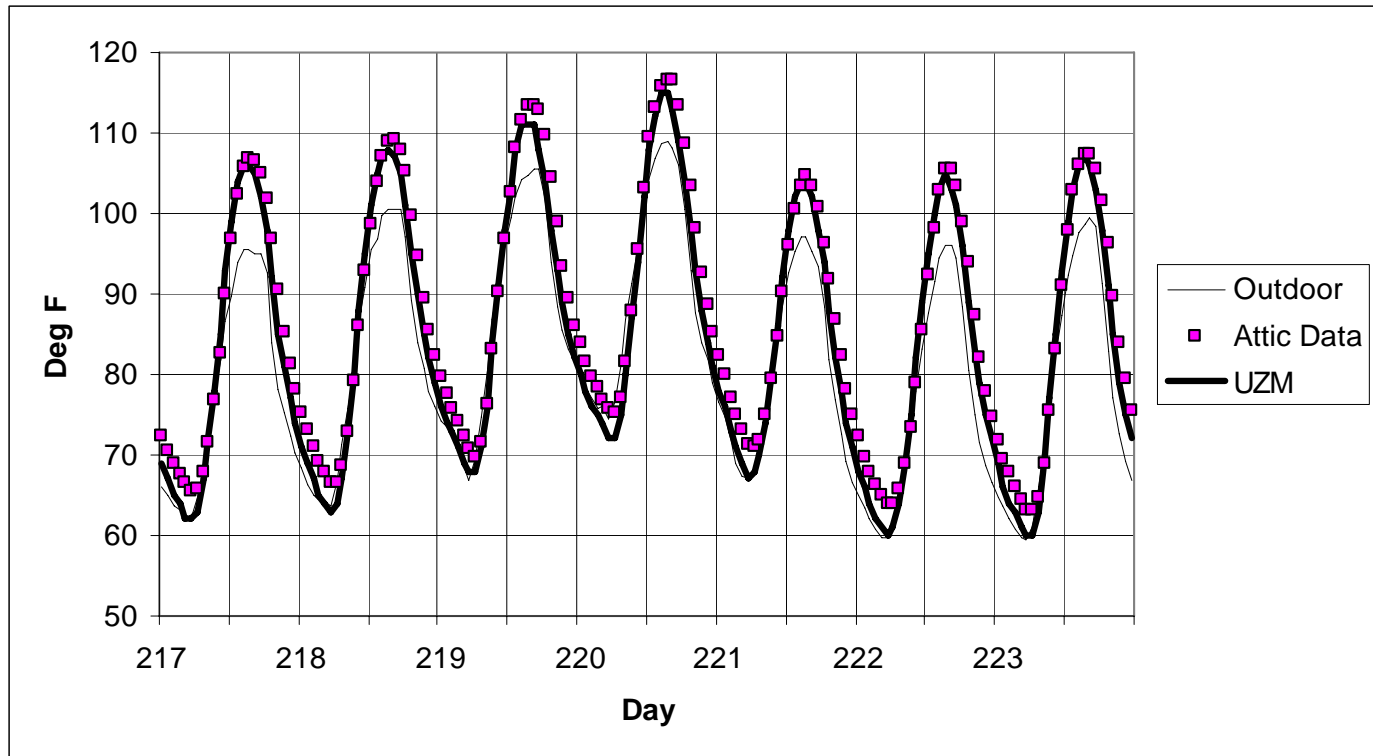
- UZM matches attic temperature pattern for week including highest attic temperature of the year
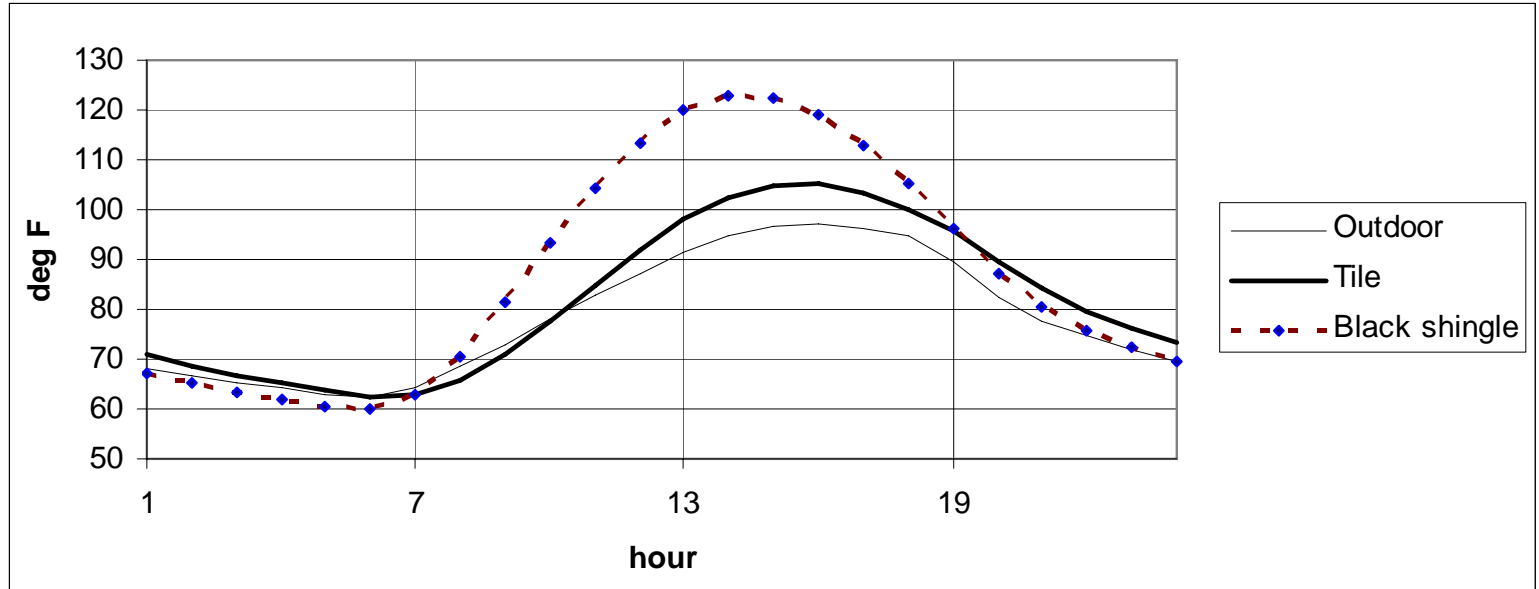
July average attic temperatures
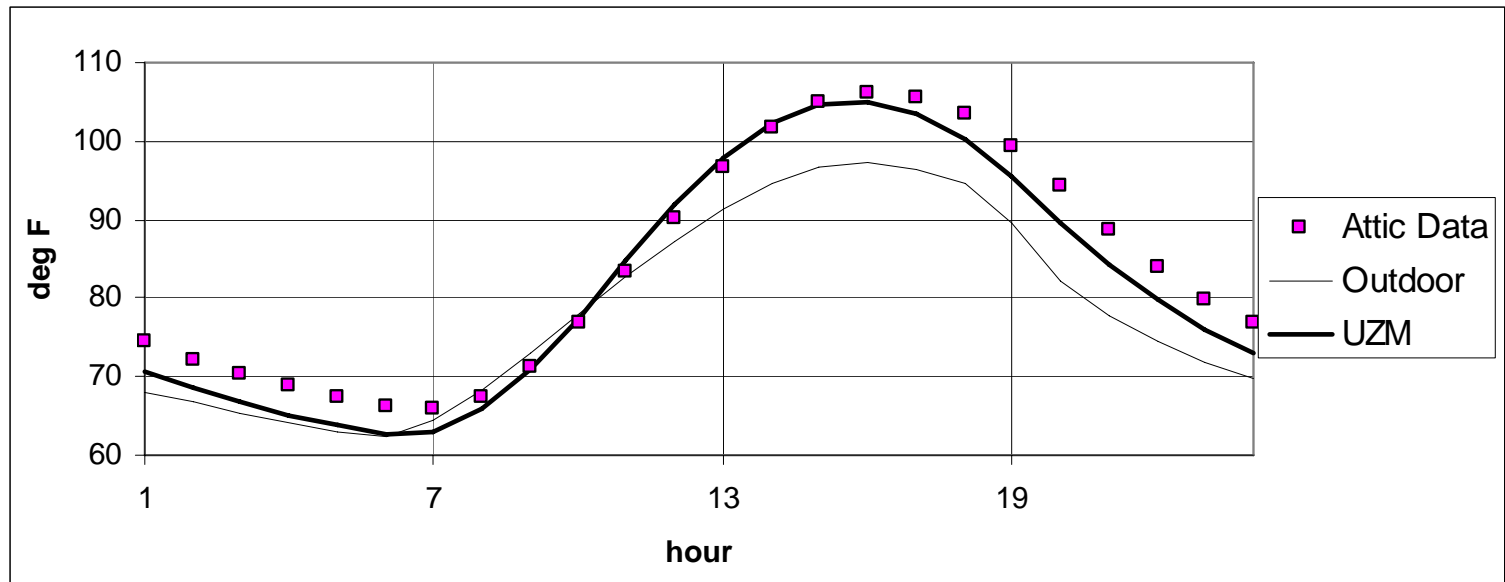
- UZM generic attic matches average measured attic temperature pretty well.

January average attic temperatures

○ UZM generic attic matches average measured attic temperature pretty well.

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Example application

- ○ UZM predicts average July attic temperatures 18 degrees F higher with black asphalt shingles compared to grey concrete roof tile