BUILDING SCIENCE
INSIGHTS
Physics to the Field™

High Performance Unvented Attics with Fiberglass Insulation

Building Science Group, Sustainability
Owens Corning

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

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Acknowledgments

Field Testing # 1

Field Testing # 2

Advanced Modeling

Mixed Climate Hot-Cold-Humid

Hot-Dry

Both Climates

- Dr. William Miller – Oak Ridge National Laboratory
- Dr. Andre Desjarlais – Oak Ridge National Laboratory
- Mikael Salonvaara – Owens Corning
- Abe Cubano –Owens Corning
- Neil Freidberg – Owens Corning

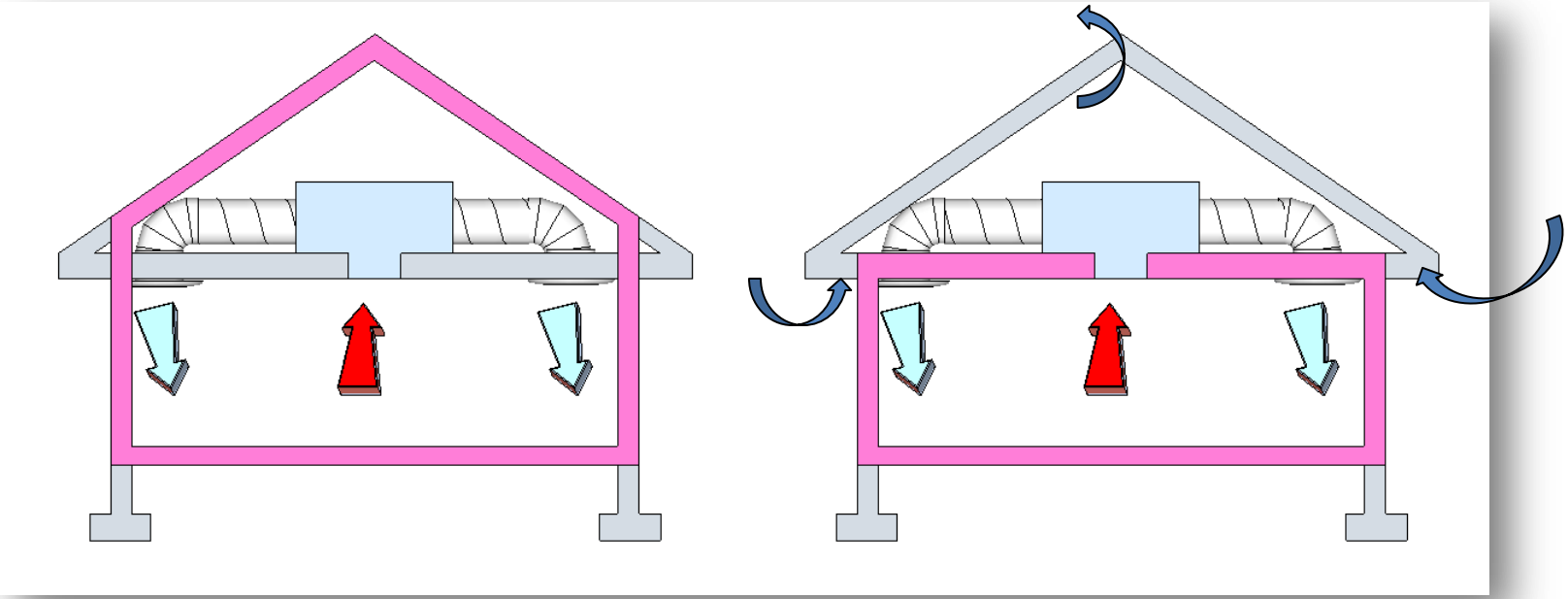
Outline

- Moisture in above and below roof deck insulation
- Impact of vented and non-vented attics on moisture in attics
- Performance Results
- Discussion and Conclusions

Attic Types and Moisture Management

Sealed (Unvented) Attic

Vented Attic



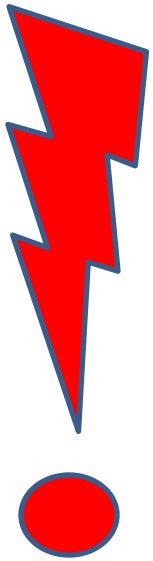
Ducts inside thermal boundary	Ducts in unconditioned space
Attic is not living space and not intentionally conditioned	Attic is ventilated with outdoor air

Approach

- Focus on moisture performance
  - Condensation, wetting and drying of roof deck
- Tools
  - Simulations with hygrothermal models
  - Field testing
    - Air tightness and temperature/humidity measurements

Typical Insulation in Unvented Attics

- Spray foam: Chemicals mixed, applied and cured on-site
  - Open Cell
    - Low density (~0.5 pcf), Vapor permeable
  - Closed Cell
    - High density (~2 pcf), Low vapor permeability



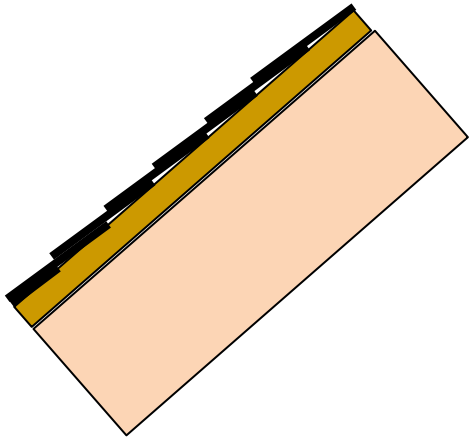
www.Insulatewithintegrity.com

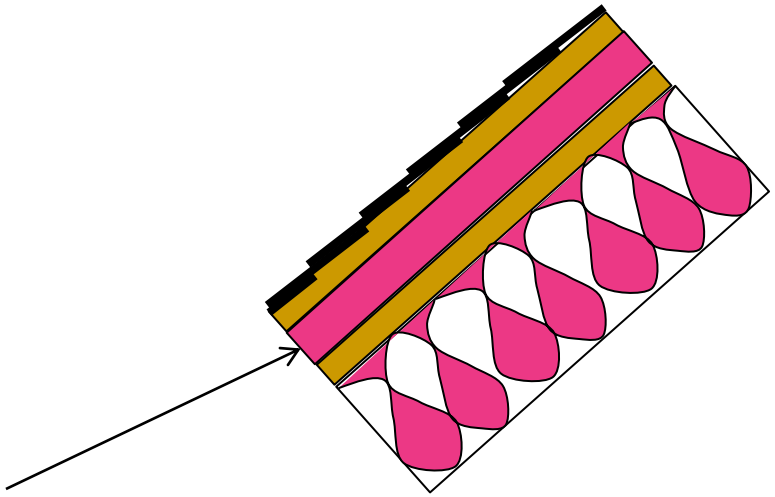
- Air permeable insulation
  - Dense packed fibrous insulation
  - Condensation control layer e.g. exterior foam may be needed

Unvented Attics in Building Codes

International Residential Code (IRC) R806.5

- "Unvented attic and unvented enclosed rafter assemblies"
  - Requires air impermeable insulation in direct contact with the roof sheathing
  - If air permeable insulation is used
    - The air permeable insulation has to be supplemented with a condensation control layer (air impermeable insulation) either on top of or under the roof sheathing.





Condensation Control - IRC

Table 3. Minimum R-values of Air-impermeable Insulation in Unvented Attics. (IRC 2012 table R806.5)

Climate Zone	Minimum rigid board or air-impermeable insulation R-value
2B and 3B tile roof only	None required
1, 2A, 2B, 3A, 3B, 3C	R-5
4C	R-10
4A, 4B	R-15
5	R-20
6	R-25
7	R-30
8	R-35

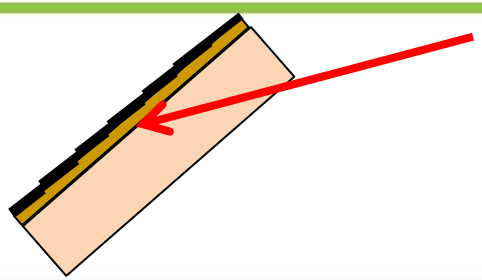
ORNL Test House – Model Calibration

MEASURED AND SIMULATED TEMPERATURE & RELATIVE HUMIDITY

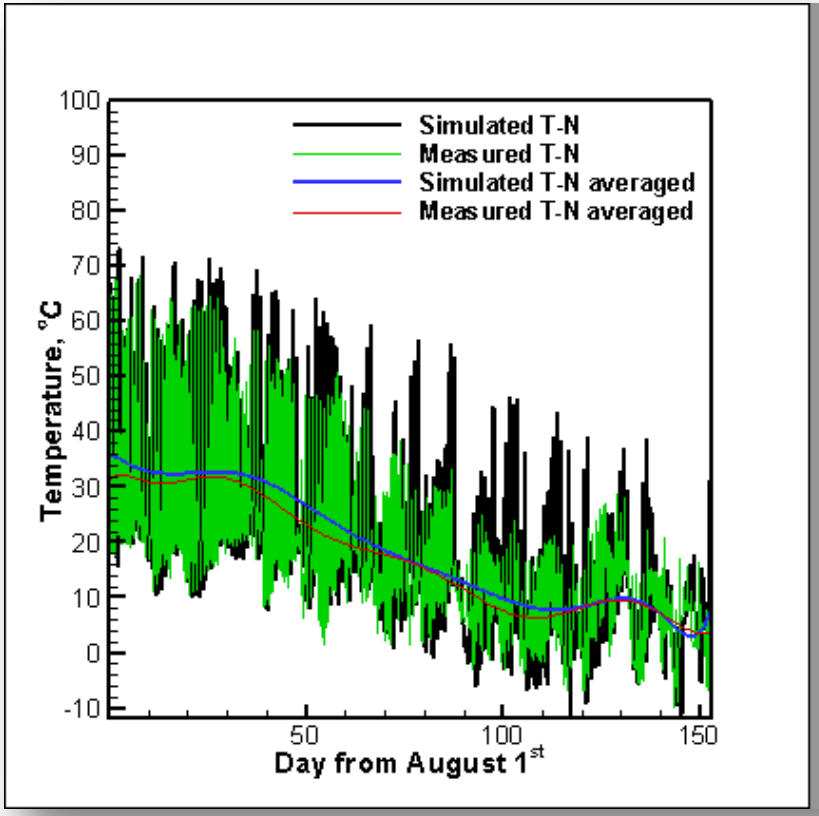
Model Calibration

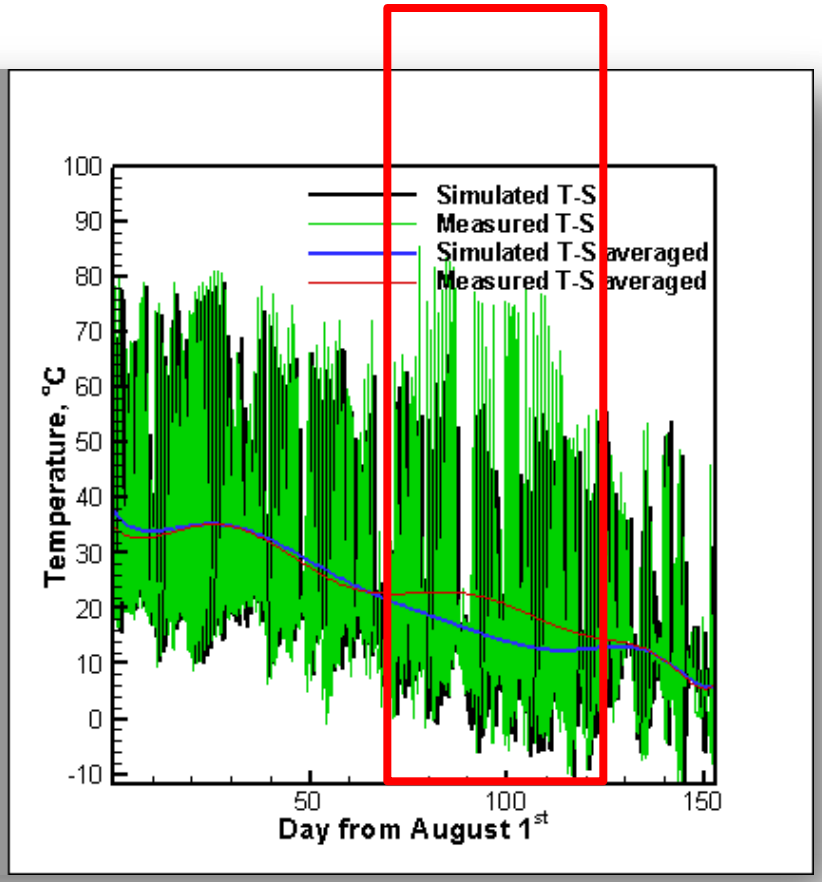
- Field Testing
  - ORNL test house with Sealed Attic
- Structure
  - Shingles
  - Underlayment
  - OSB
  - 1” Closed Cell **
  - ~5” Open Cell
  - Spray-on fiber glass insulation 2”

Measured and Simulated Temperature

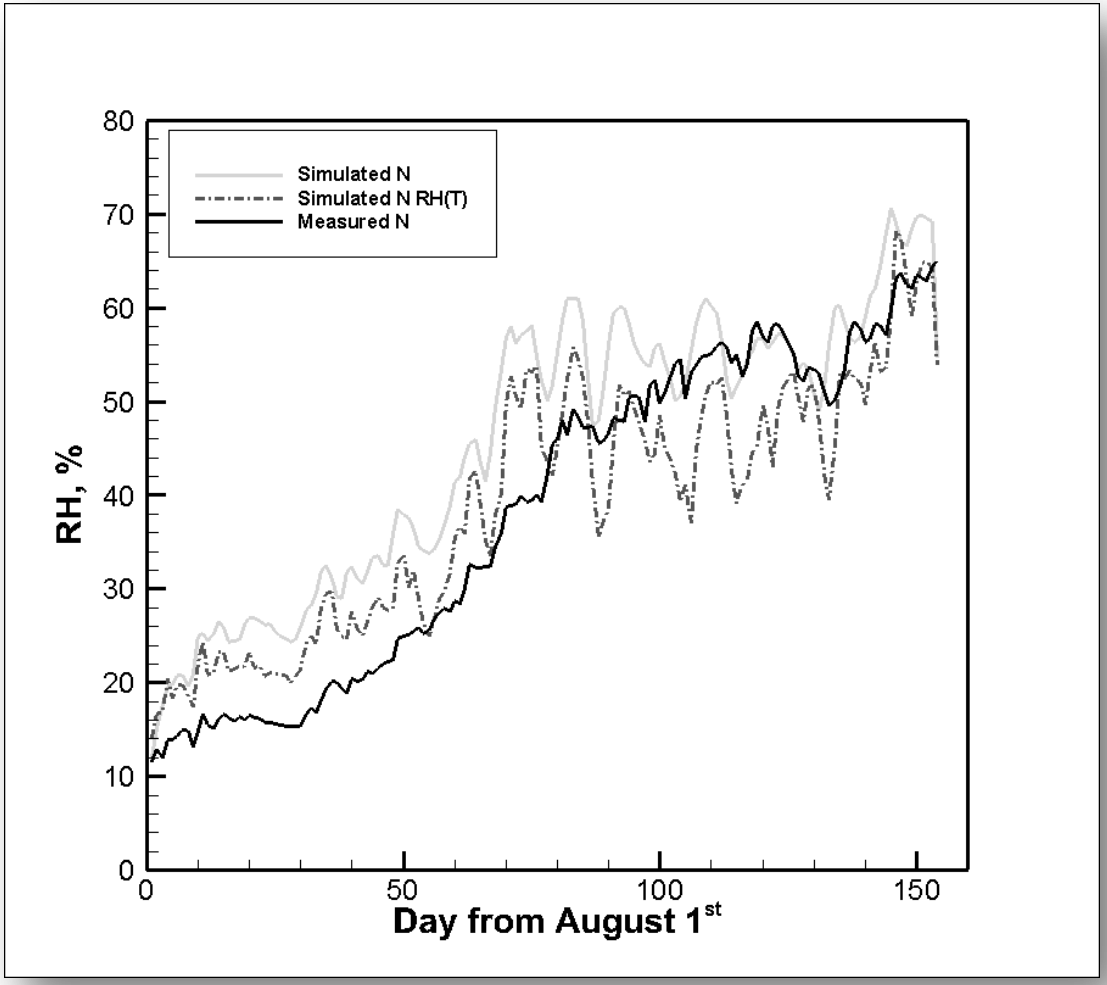


Temporary plastic on top of roof





Measured and Simulated Relative Humidity



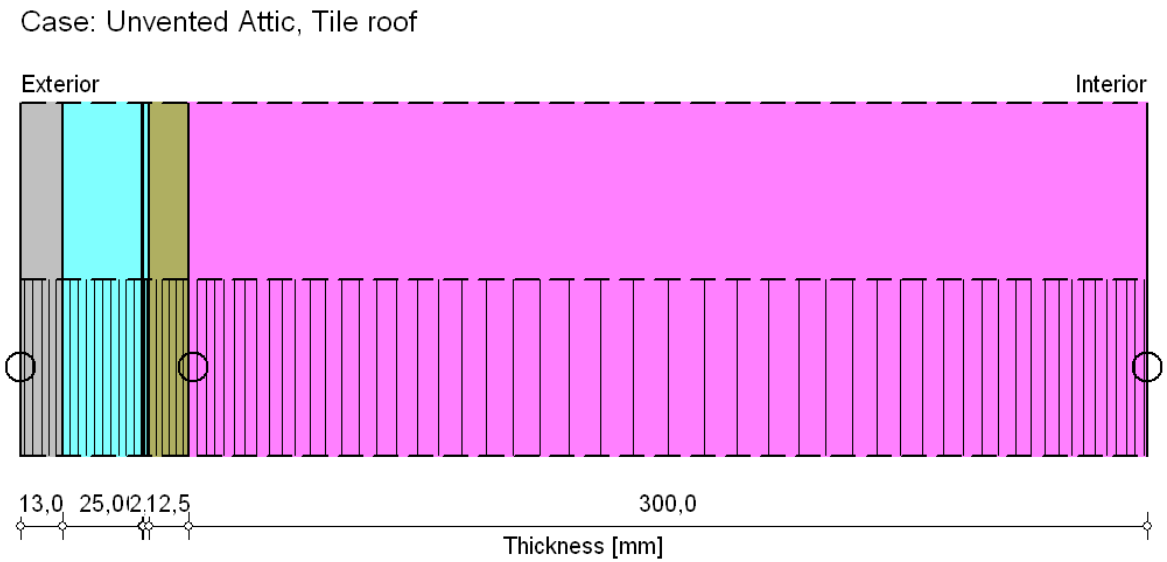
Climate zones 3B

ROOF DECK MOISTURE – MODELING OF DEMO HOUSE

Roof Assembly

Component Assembly

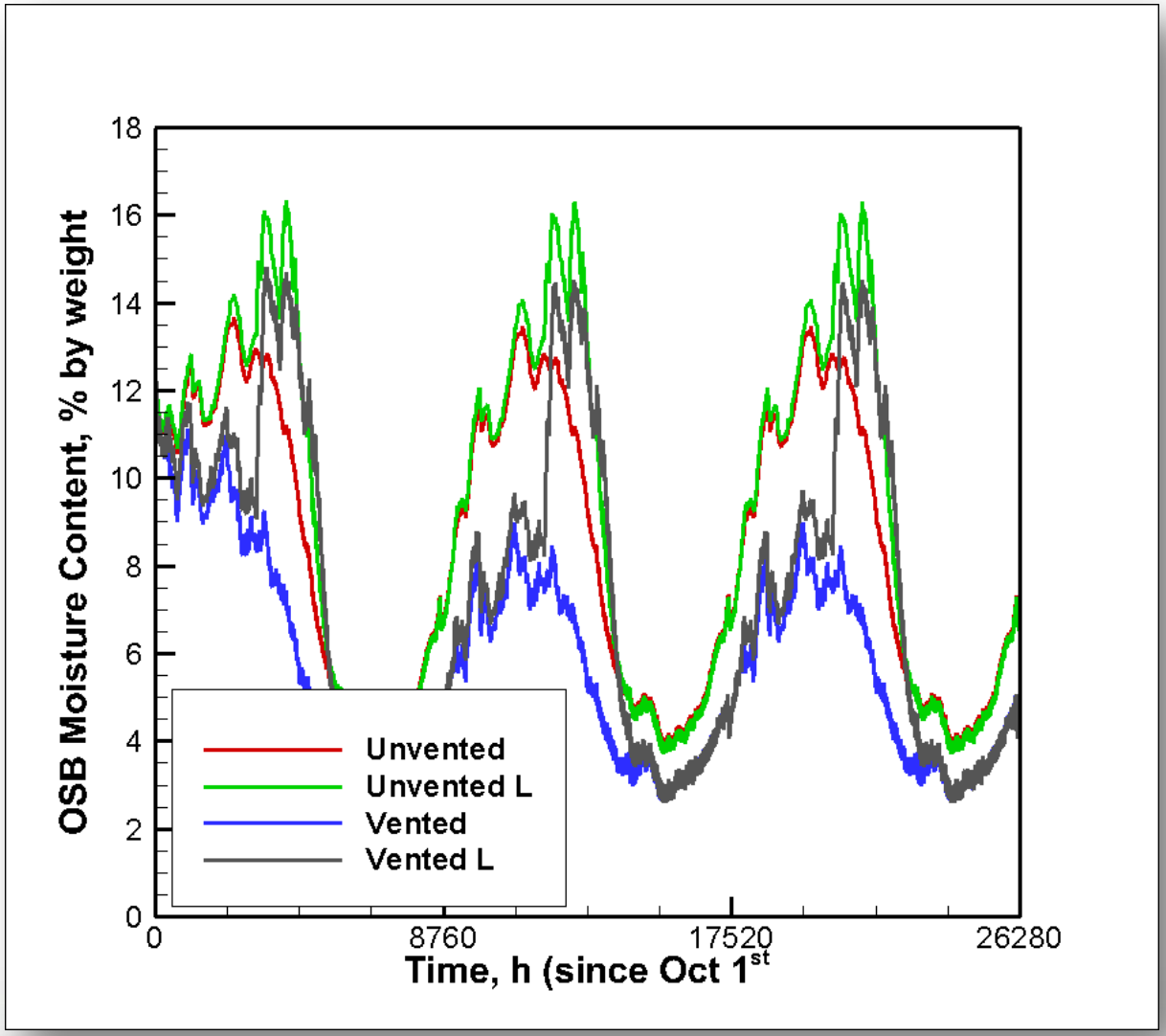
WUFI Model



- The layers in the roof listed – from exterior to interior – are:
  - Roof tile
  - 1” Air gap
  - Roofing underlayment
  - ½” Roof sheathing (OSB) and
  - Fiberglass insulation.

ASHRAE 160

OSB moisture content in Unvented and Vented attics



Climate zones 3B

San Marcos, CA

More forgiveness in Ventilated Attics

Fiberglass solution Works well for Unvented Attics

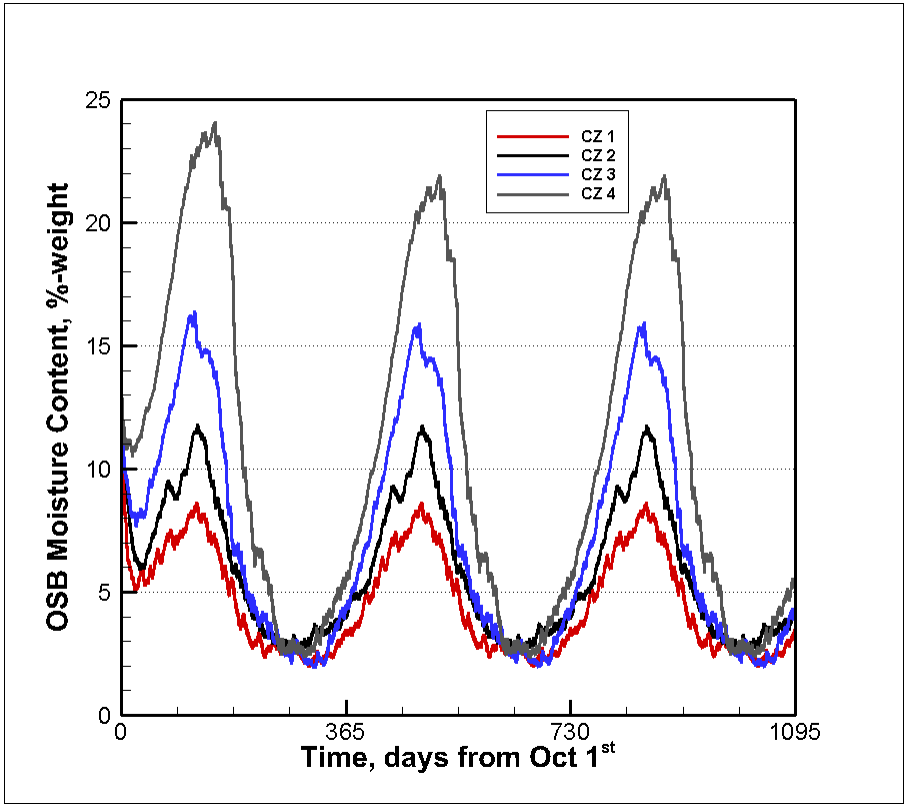
Roof Deck Performance Results

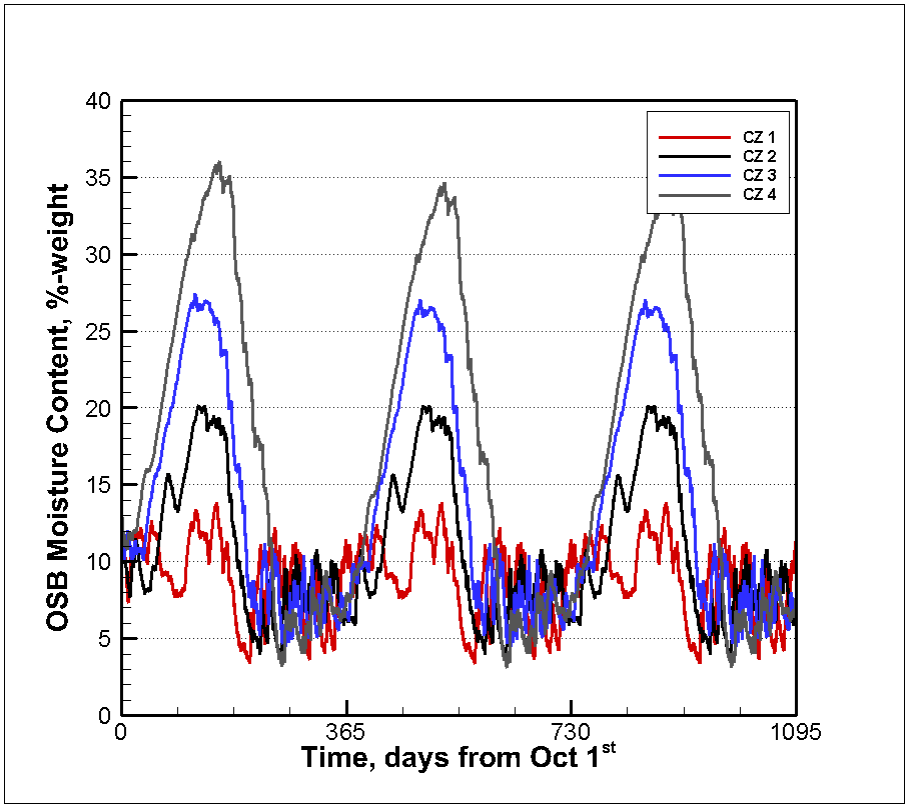
- Unvented Attic

- Climate Zone and City
- Indoor moisture loads +4 g/m^3
- Focus on Roof Deck Moisture (OSB)

1	Miami, FL
2	Houston, TX
3	Atlanta, GA
4	Baltimore, MD

Unvented Attic – Roof Deck Moisture



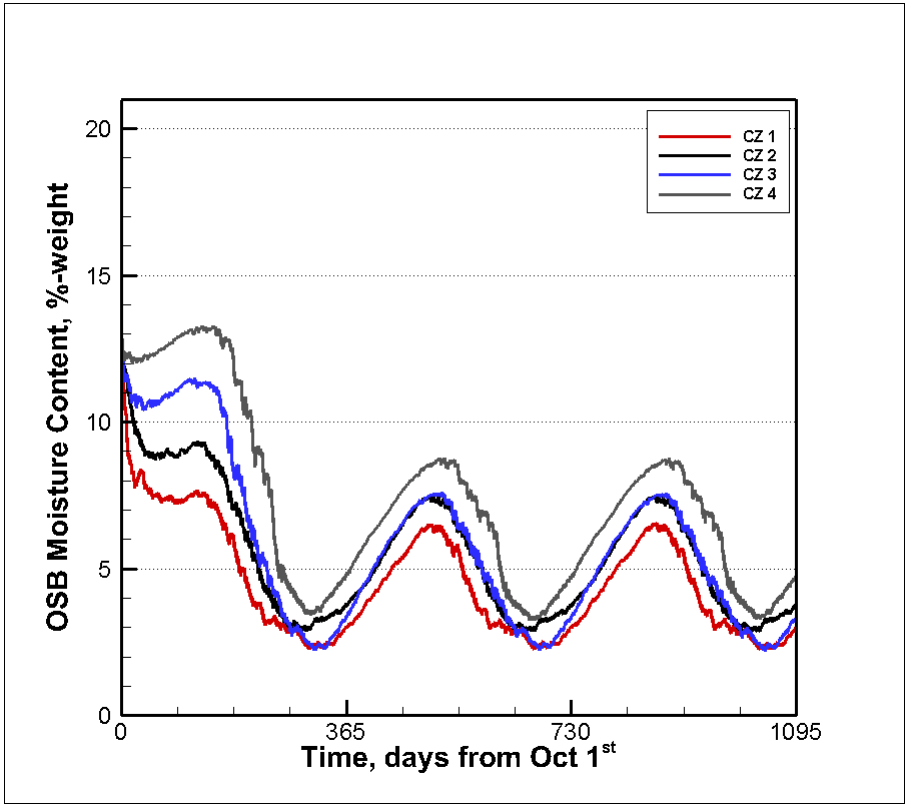


No water intrusion

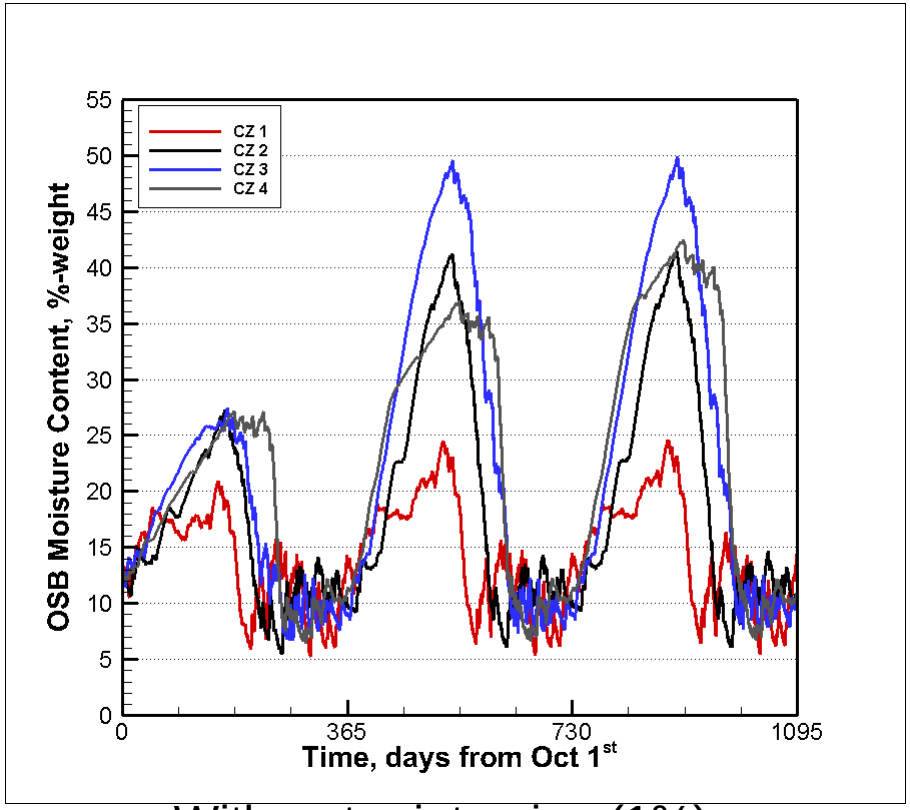
With water intrusion (1%)

Open Cell A2 (54 perm-in)

Unvented Attic – Roof Deck Moisture



No water intrusion

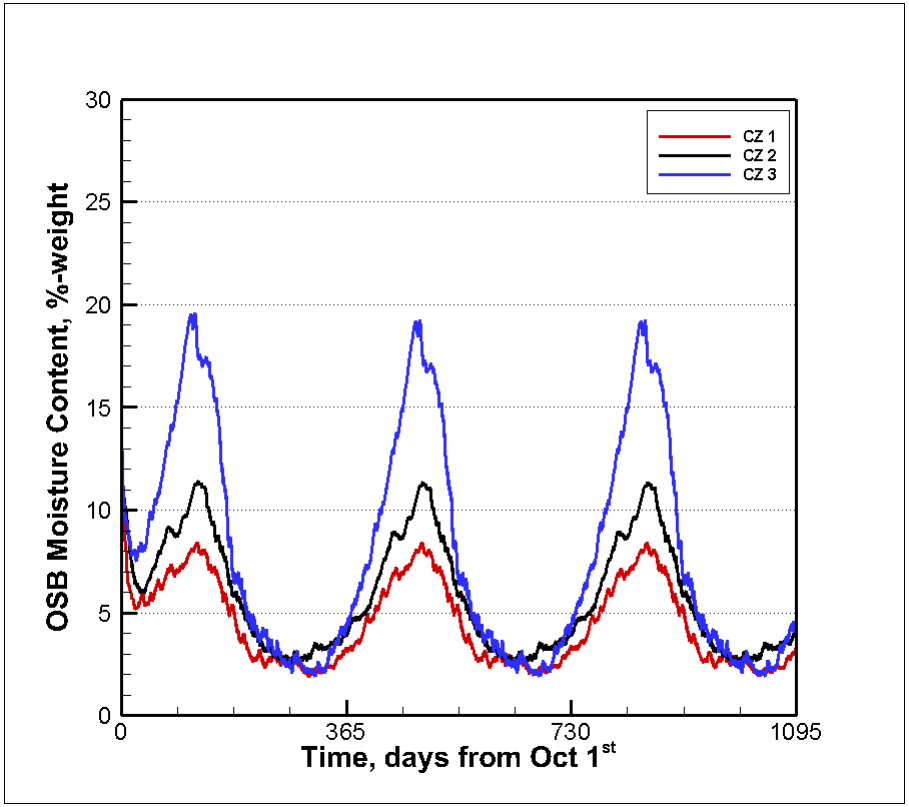


With water intrusion (1%)

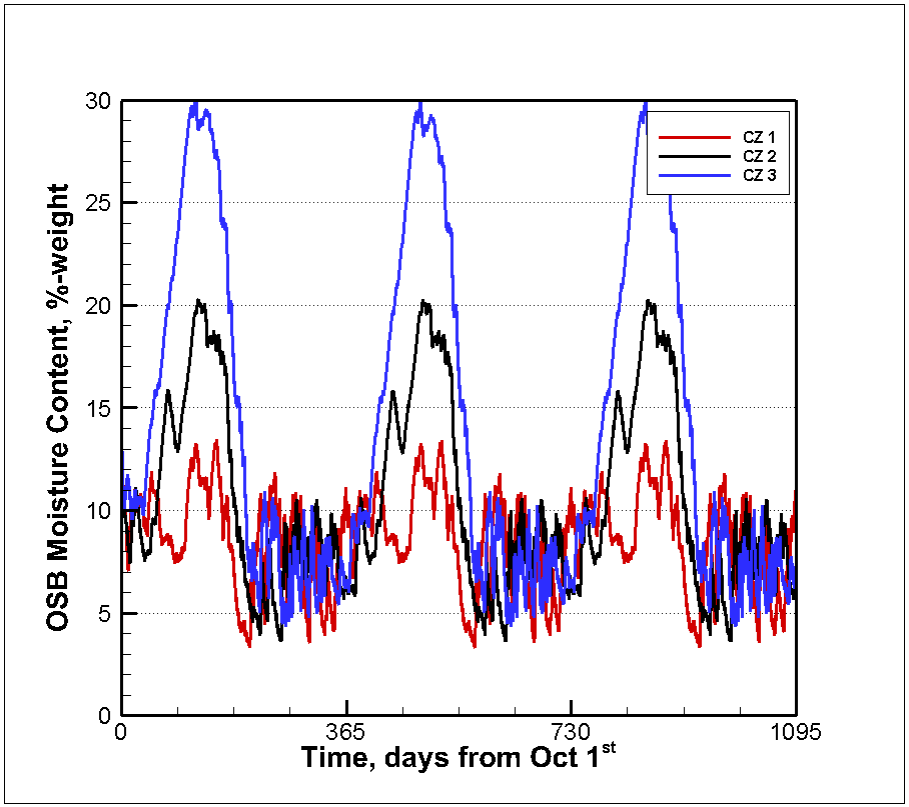
Open Cell A1 + Intumescent Coating (1-3 perms)

Note: Closed Cell foam is even more vapor tight than the above

Unvented Attic – Roof Deck Moisture



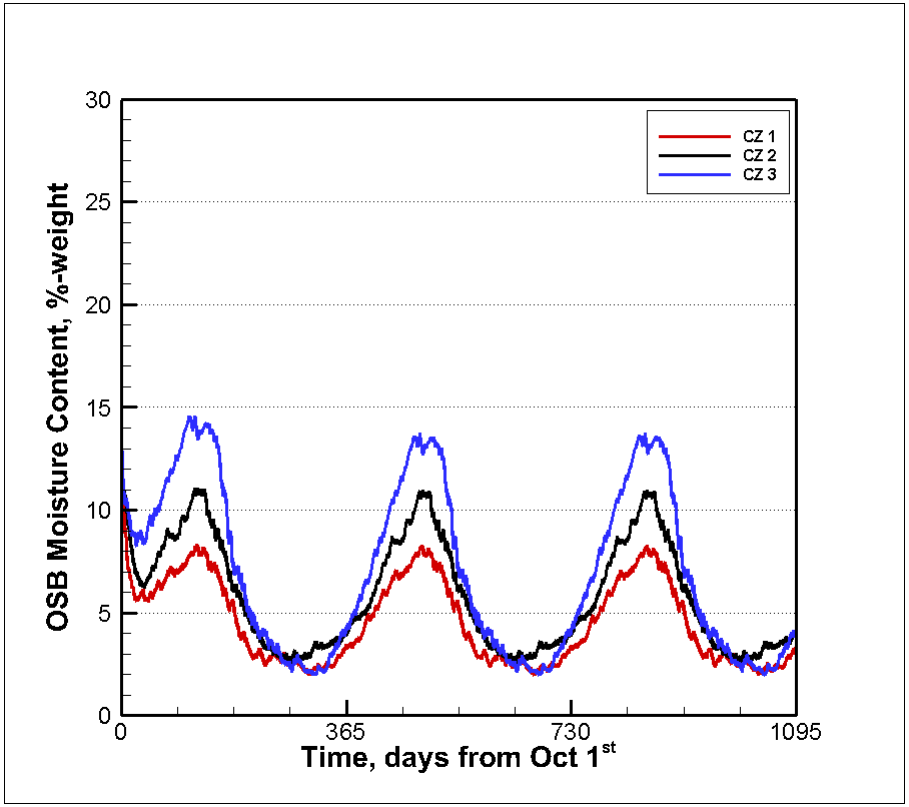
No water intrusion



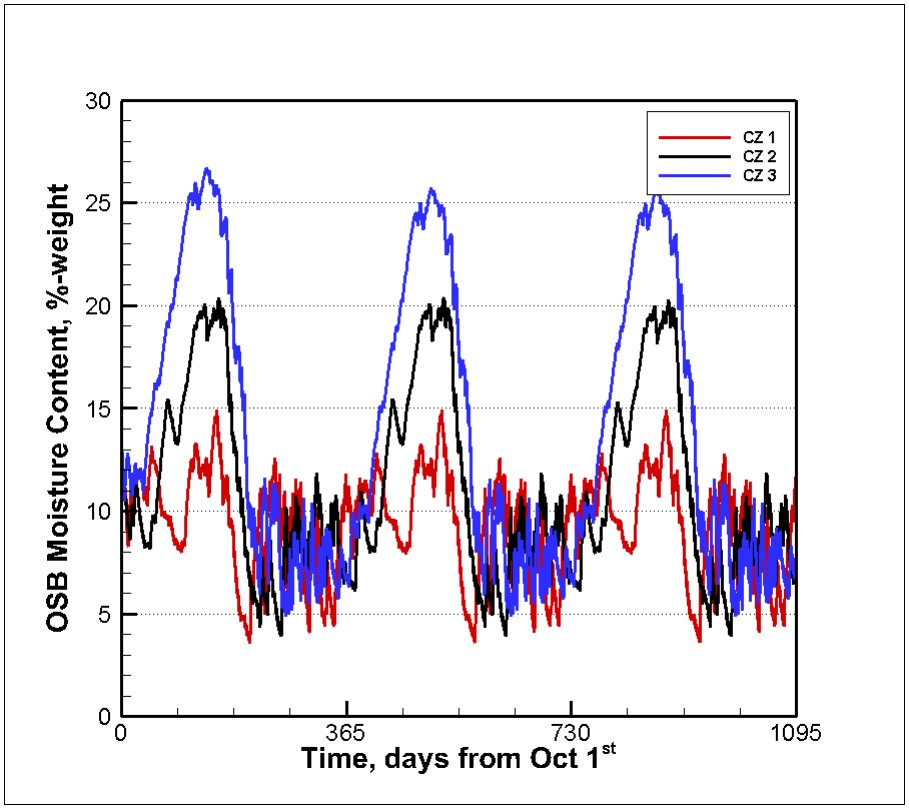
With water intrusion (1%)

Fiberglass Insulation (100 perm-in) + Air sealing

Unvented Attic – Roof Deck Moisture



No water intrusion

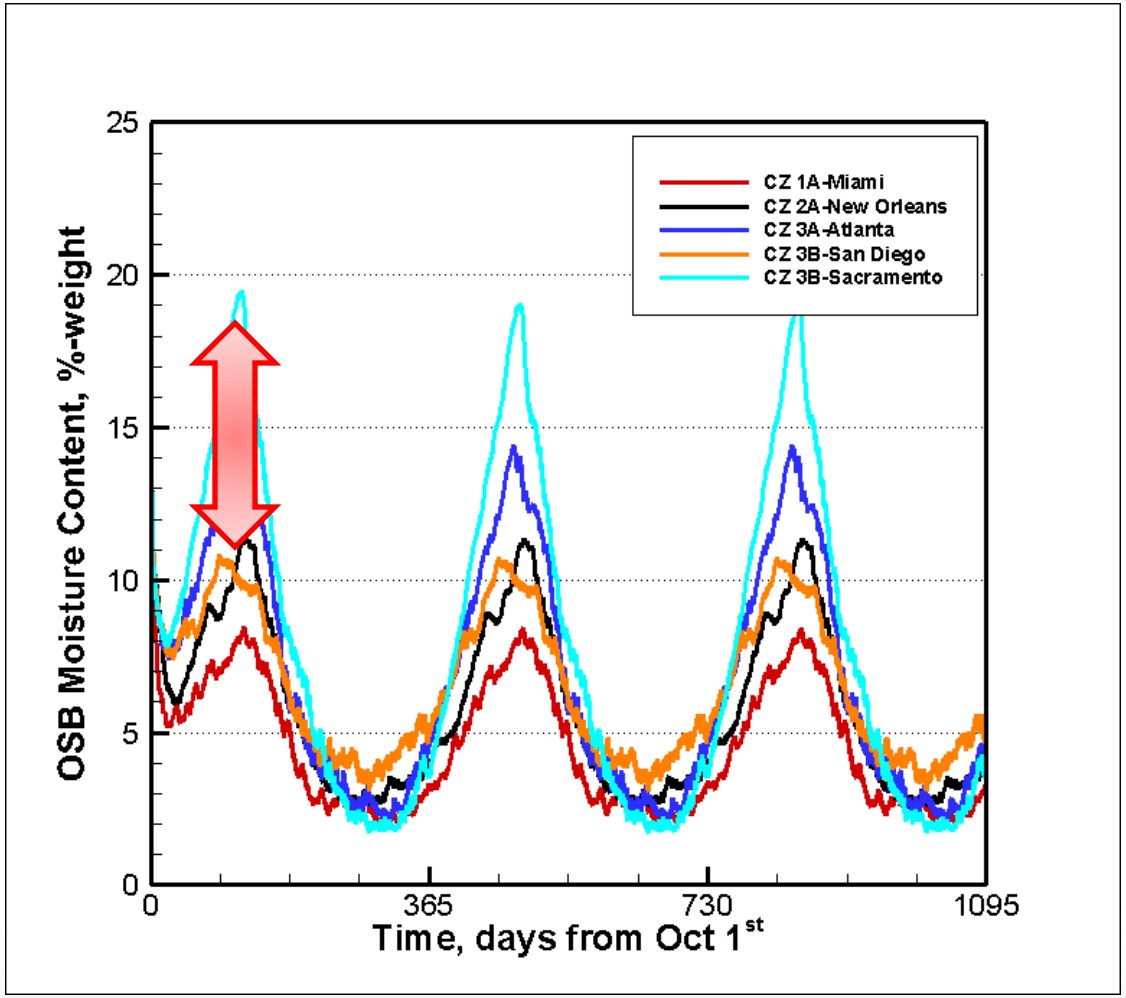


With water intrusion (1%)

Fiberglass Insulation (100 perm-in) +
Air sealing +10 perm VR

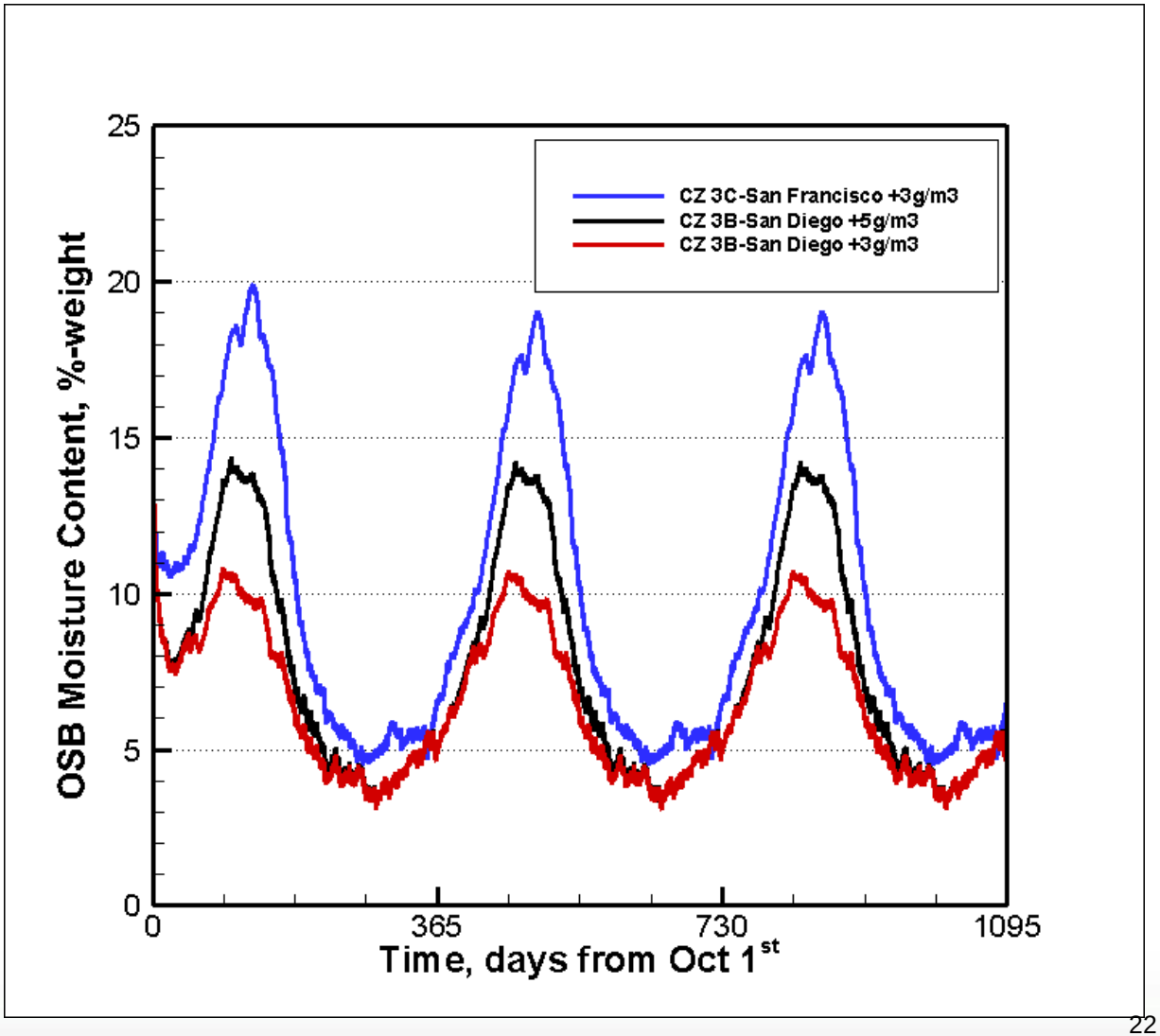
Climate Makes a Difference

- Hot to Cold, Wet to Dry climates (CZs 1-3)



Asphalt FG

Climate vs Moisture Load

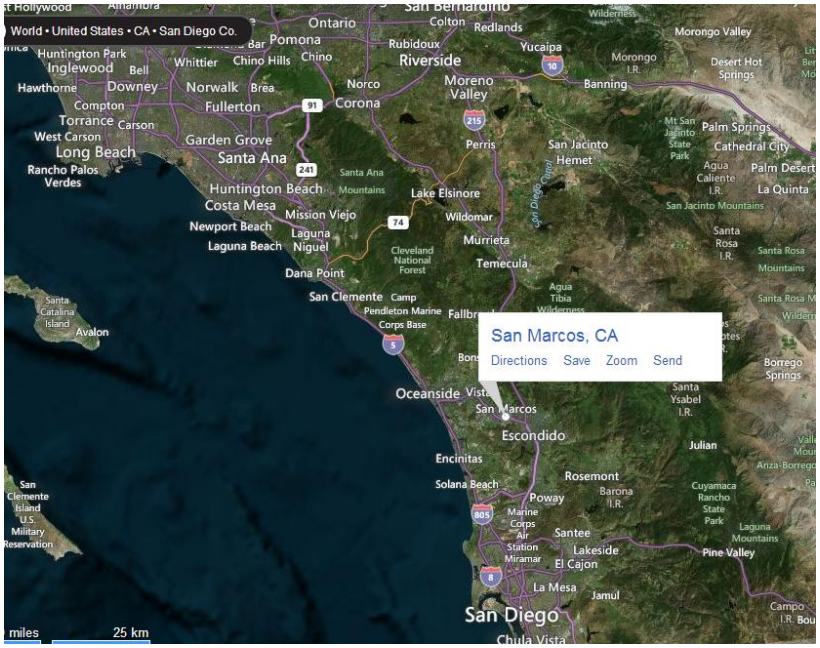


San Francisco
CZ3C, sensitive

San Diego, high moisture load causes no problems

Asphalt shingles

FIELD HOME – SAN MARCOS CALIFORNIA



KB Homes

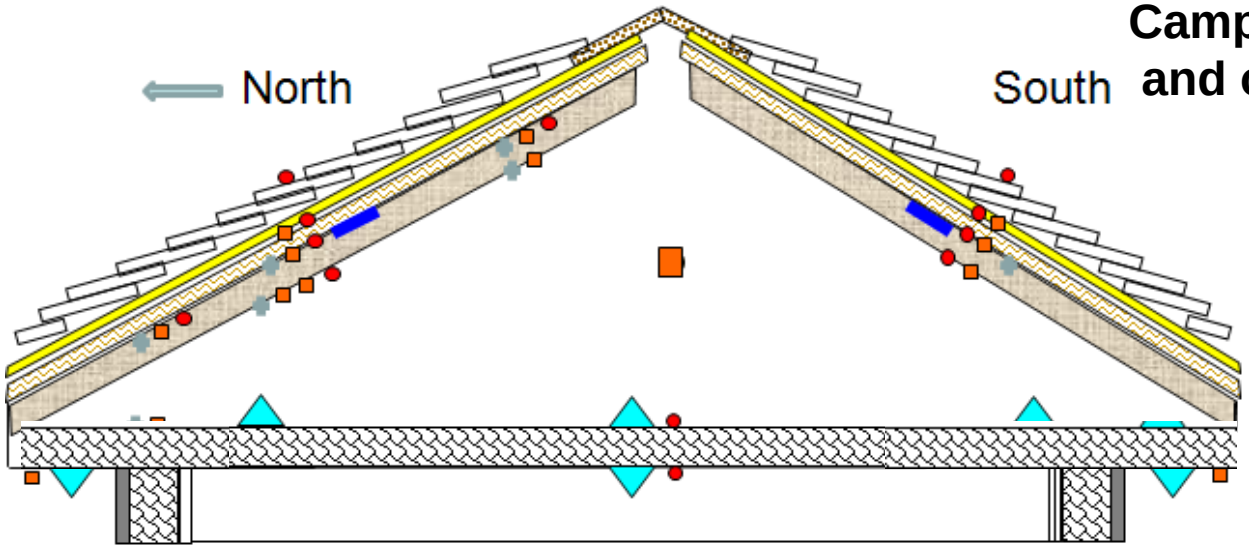
24-hr Average Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
°C	11.1	12.1	12.8	14.0	15.2	16.8	18.5	19.3	18.7	16.8	13.6	11.2	15.0
°F	52.0	53.8	55.0	57.2	59.4	62.2	65.3	66.7	65.7	62.2	56.5	52.2	59.0

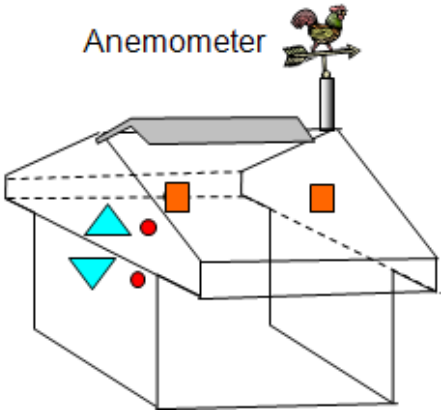
Sealed Attic

Instrumentation Plan

Campbell Scientific Model CR23X and or CR10X micro-loggers



- Temp
- Temp & Rh
- Moisture Pin
- Heat flux
- Differential Pressure

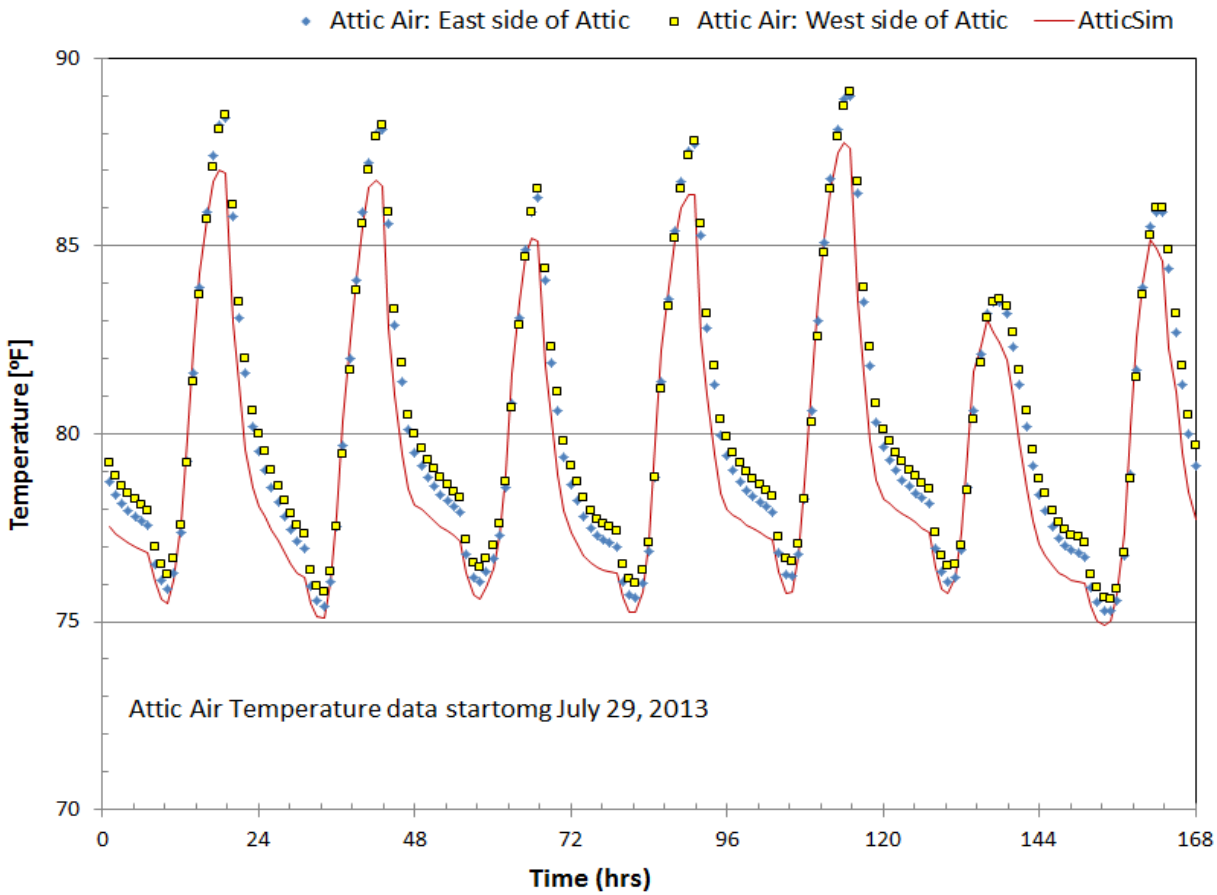


- Roof surface temperatures
- Roof sheathing temperatures, humidity and moisture content
- Attic air temperatures north and south side of attic
- I ndoor air temperature at thermostat
- Weather conditions
- Whole-house energy use
- HVAC run time.

Building Electrical Monitoring Points		
Wattnode transducer	Model WNA-1P-240-P	Whole House Power
ACL1 Event counter	OPTI-Line Monitor with DC power supplied by data logger	HVAC On Time

Computer Simulations

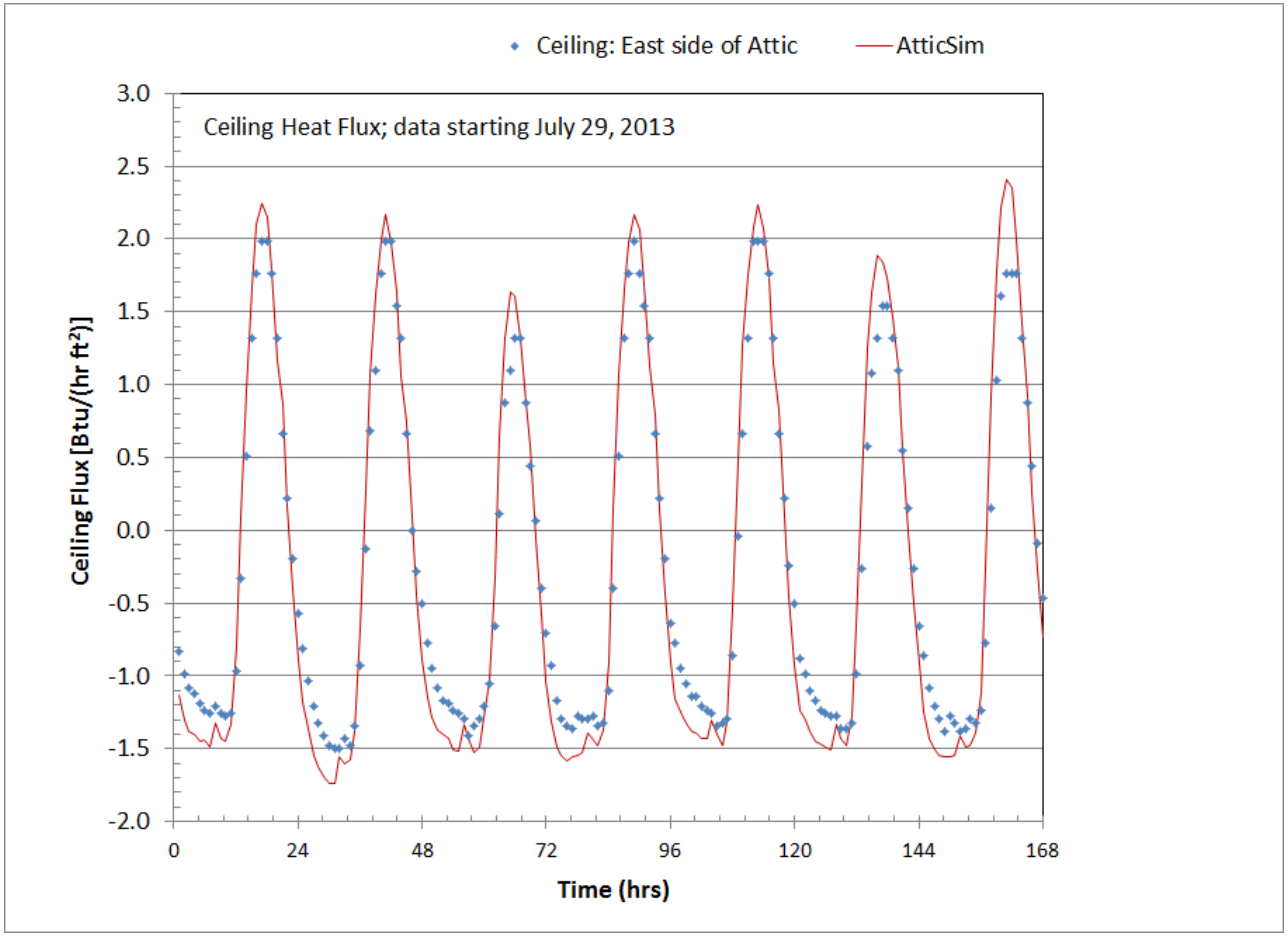
- Validation of AtticSim: Measured vs Simulated Attic T



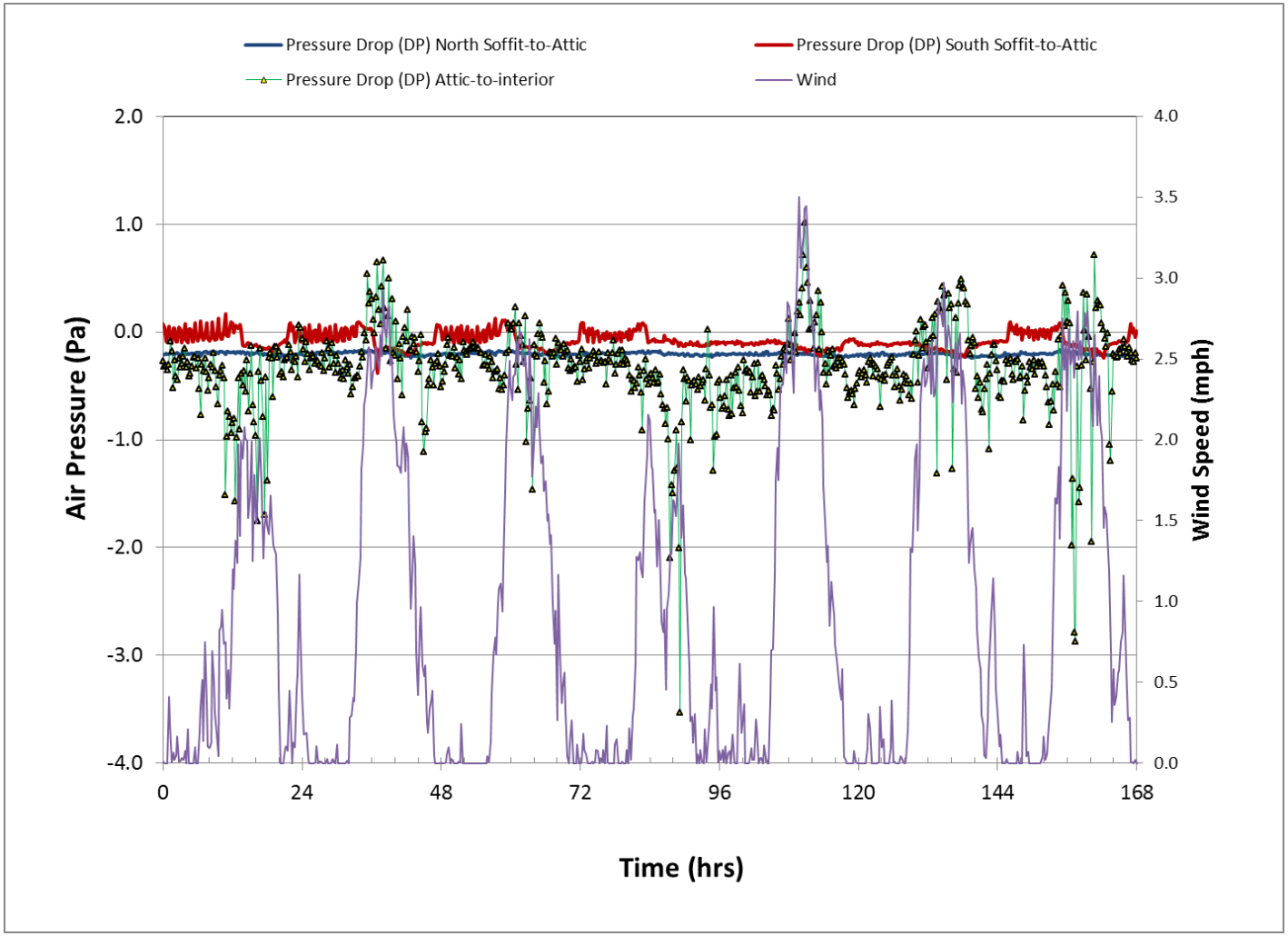
AtticSim (version 12.6)

Energy Performance

- Ceiling heat flux



Air Pressure across attic floor varies ±1 Pa

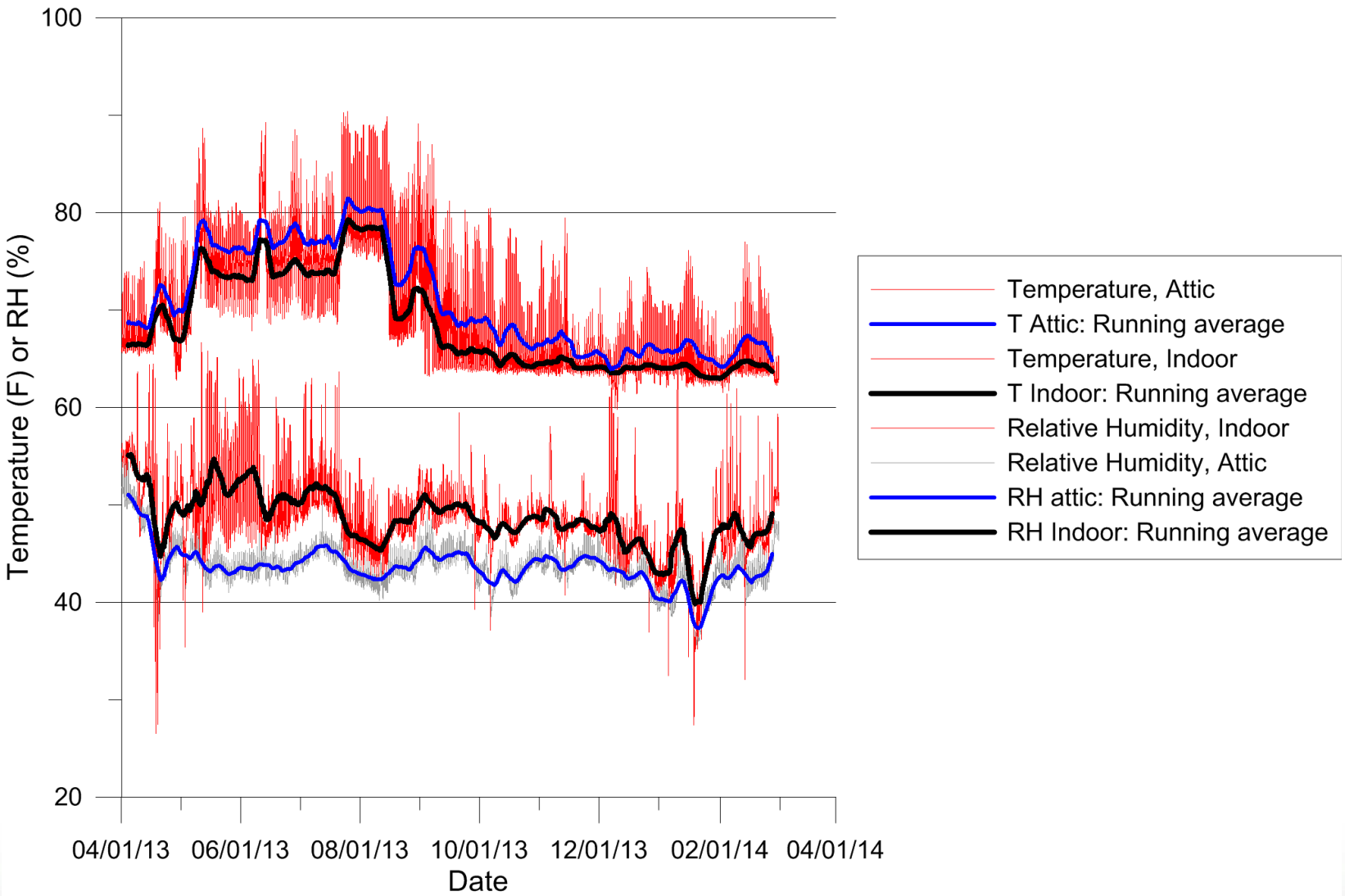


Wind affects attic-to-indoor pressure gradient

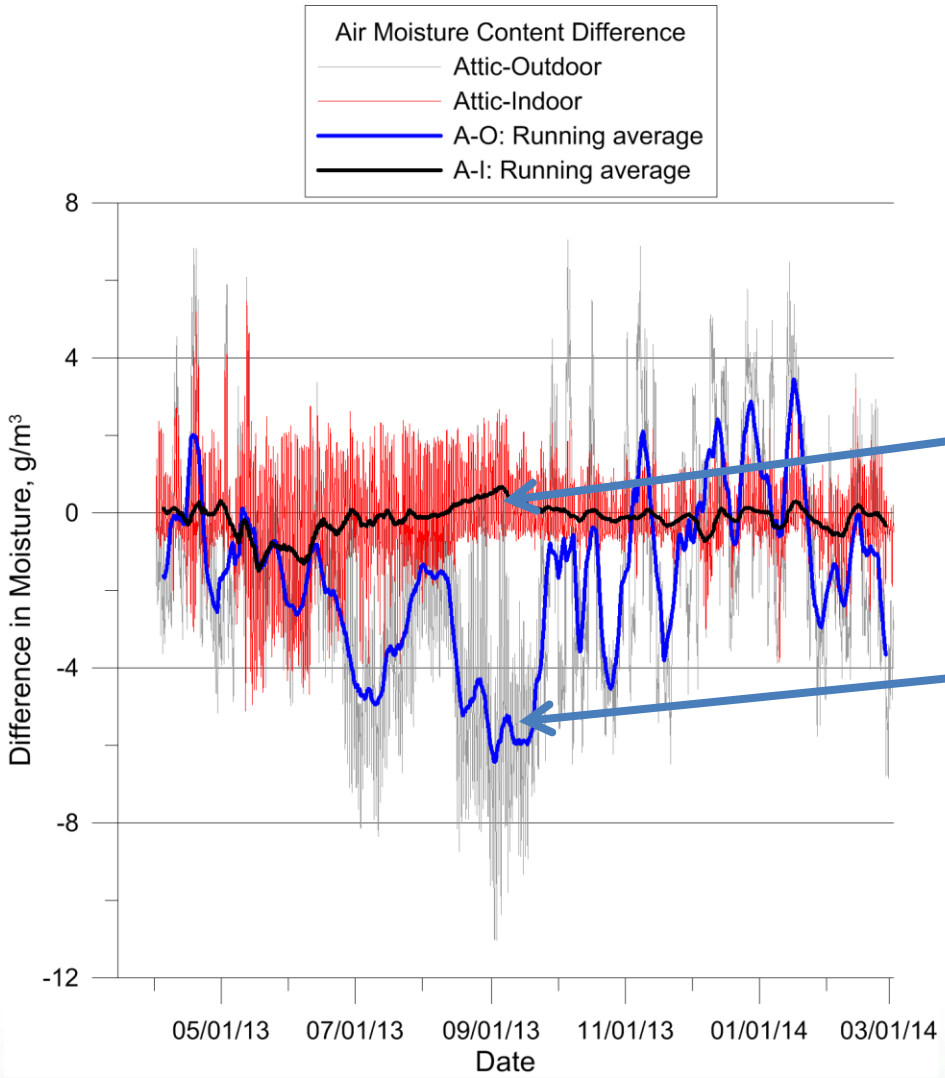
Minimal air leakage at soffits

Data collected August 26, 2013

Attic and Indoor T and RH



Moisture Loads



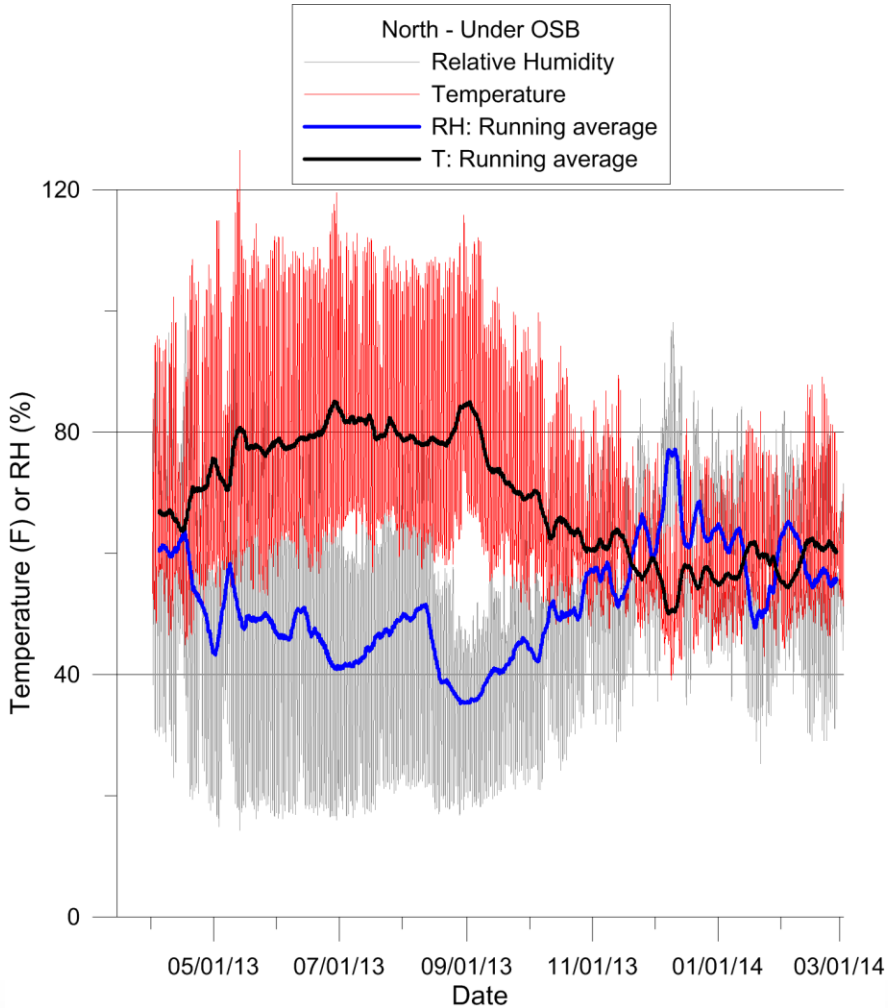
Indoor=Air Return

Attic air has about the same moisture content as indoor air

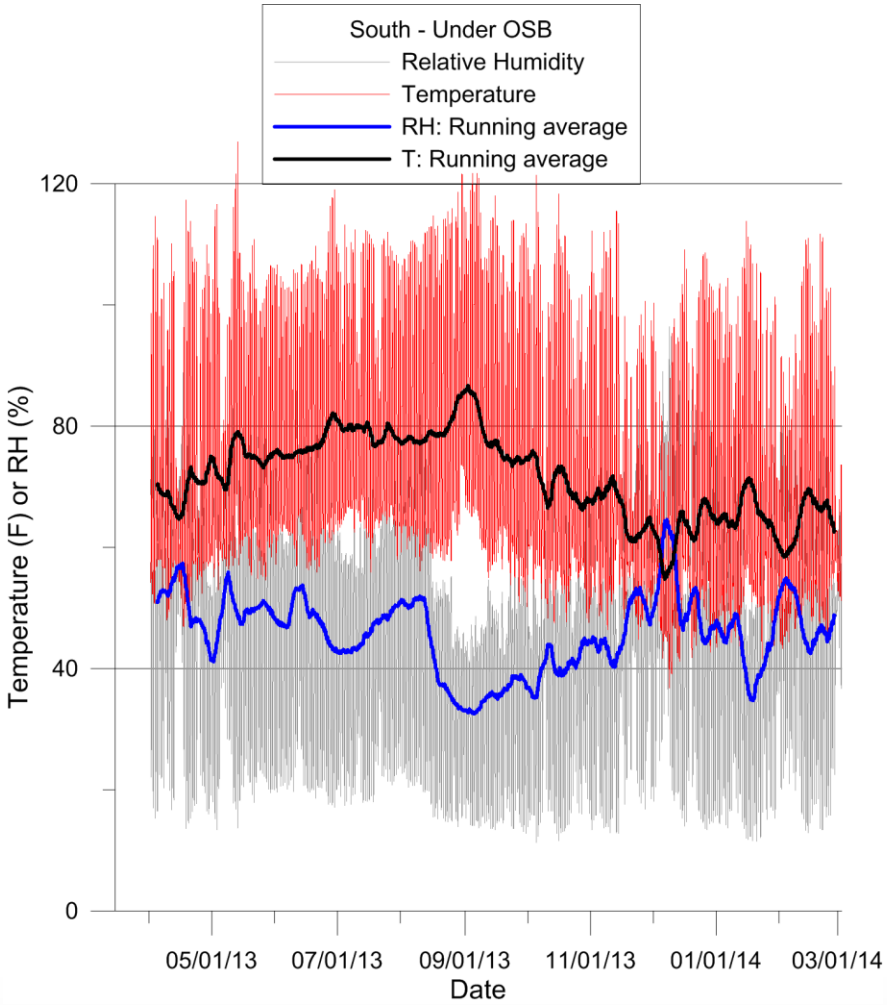
Attic/Indoor is drier than outdoors most of the year

T/RH Under Roof Deck

North

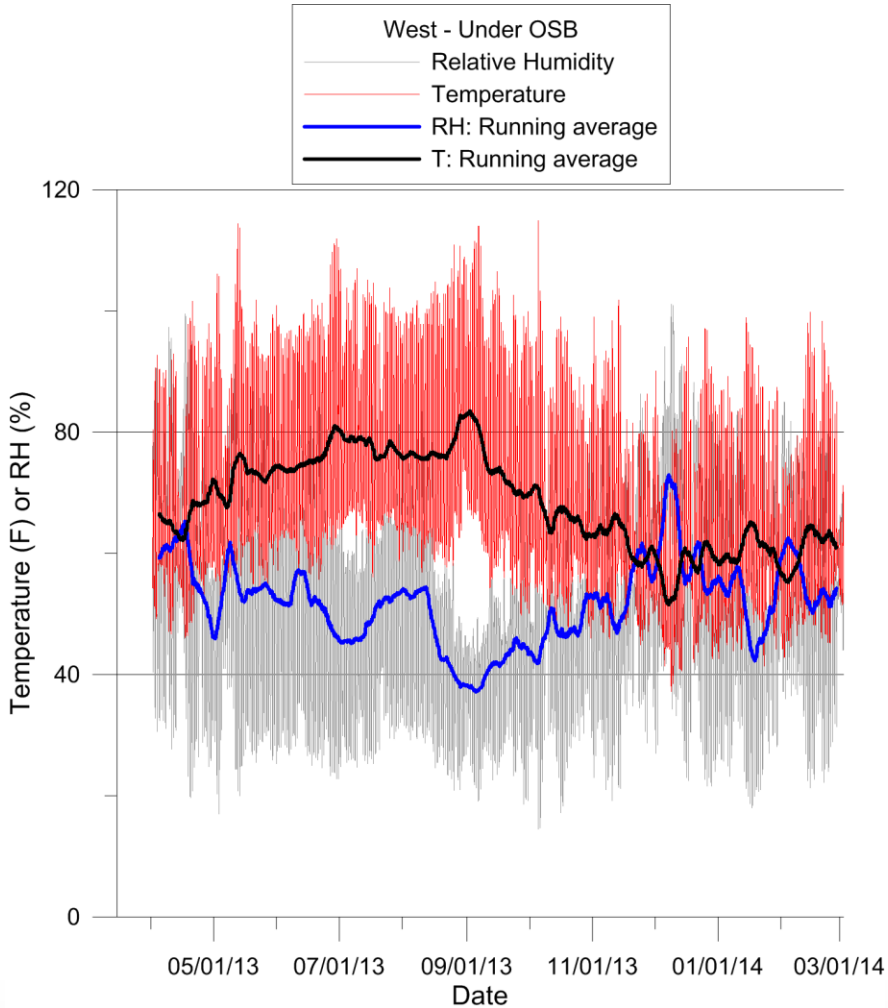


South

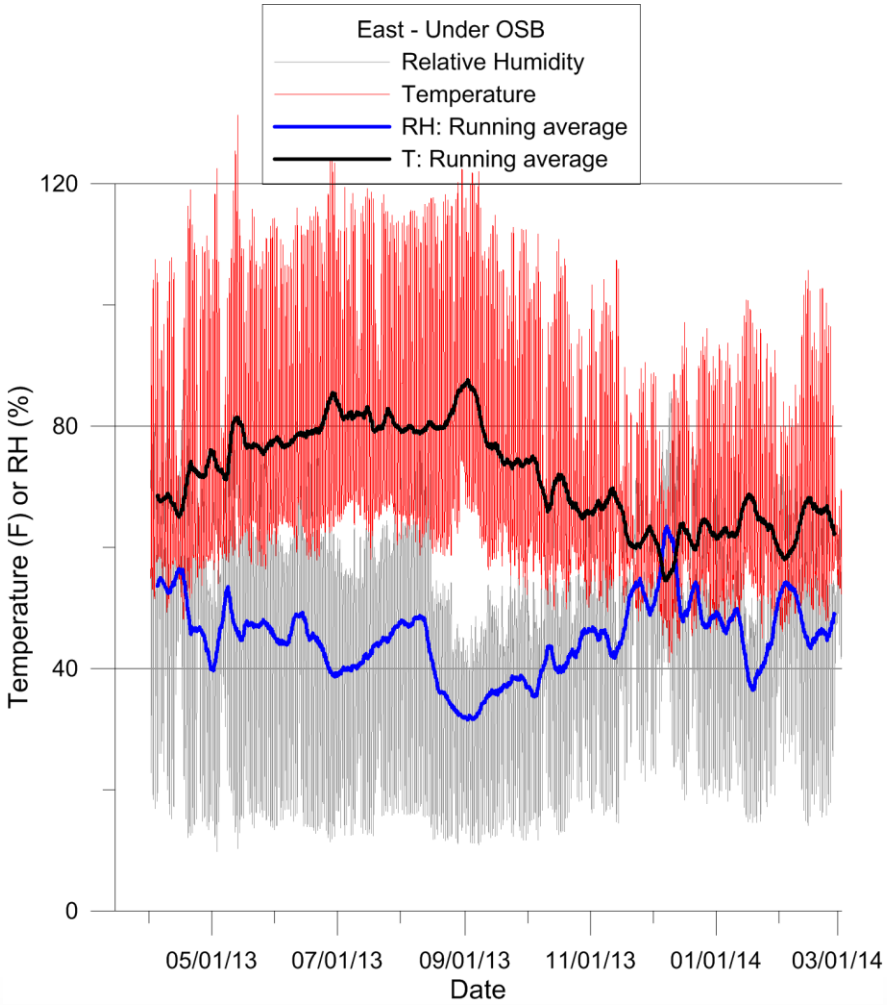


T/RH Under Roof Deck

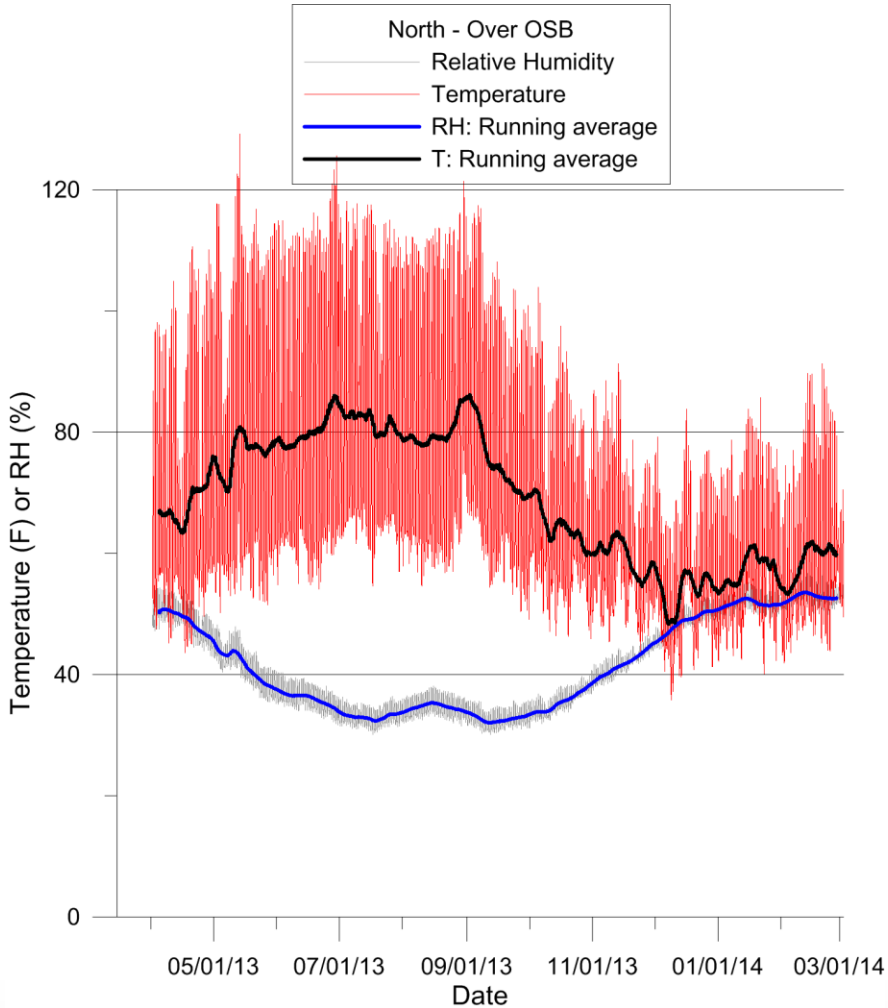
West

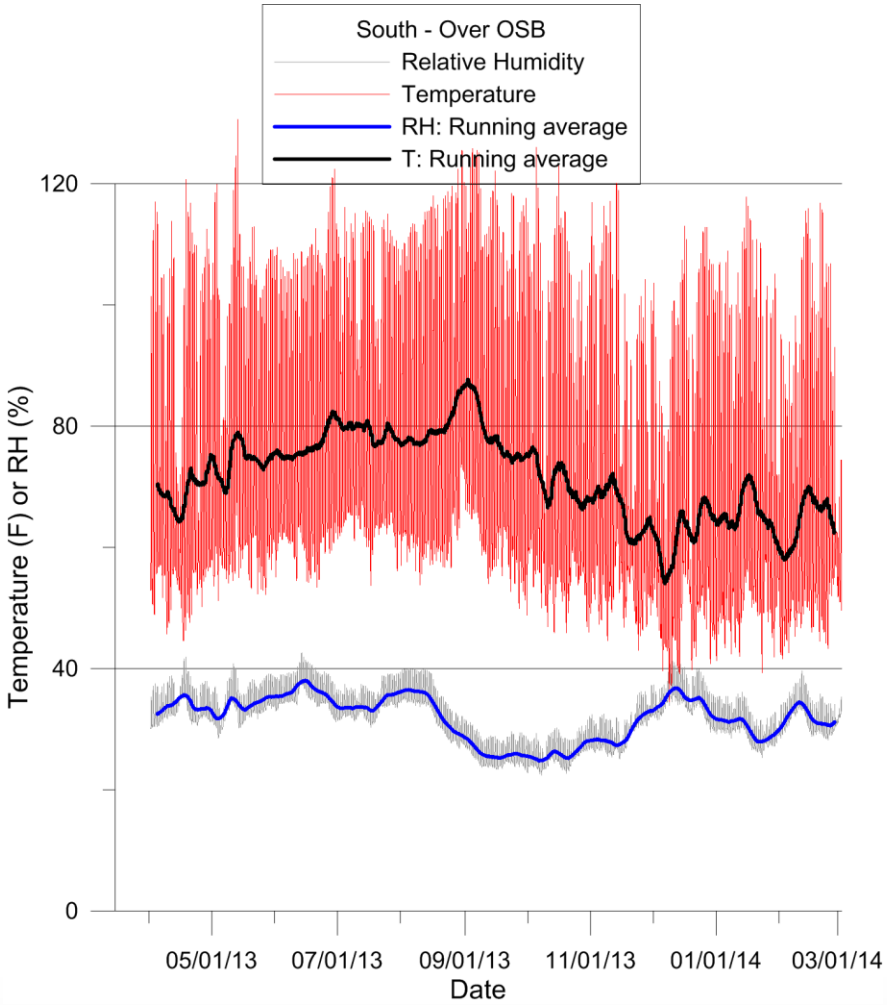


East



T/RH Over Roof Deck



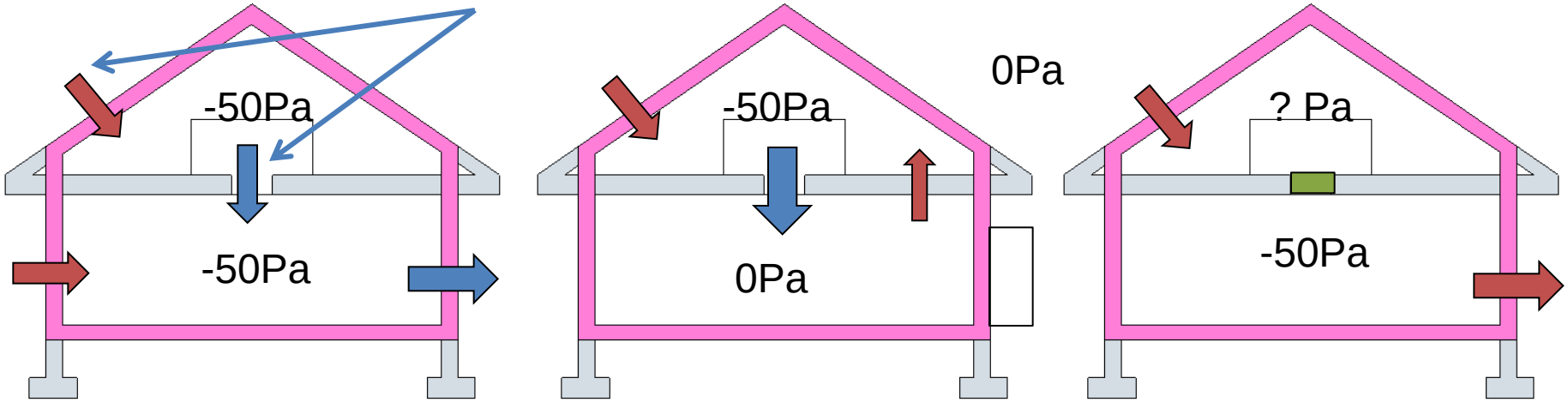


Roof Deck Air Leakage

- Air leakage between attic and outdoors must be understood
  - Is the attic ‘sealed’?
- Dual blower door testing is needed to separate component leakage

Air Tightness of the Attic

- Testing to separate Attic-to-Outdoors and Attic-to-Indoors air leakage characteristics
- Methods
  - Dual Blower Door: = Blower door flow
  - Multi-scenario tests at multiple pressure levels



Attic-to-Outdoors Air Leakage

- Fiberglass attics
  - First house (San Marcos) cfm50=515
  - Second house (Lancaster) cfm50=369
- SPF attic
  - Knoxville, TN: cfm50=336

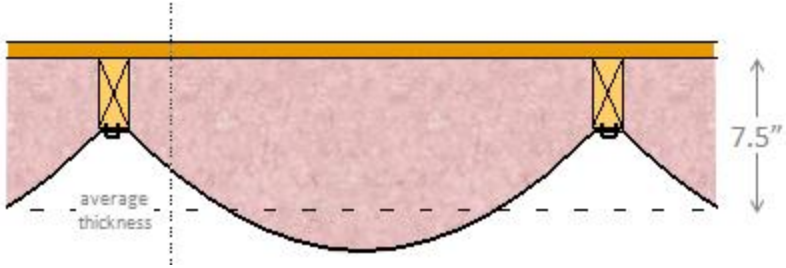
- First house was ‘test and learn’
- Second house shows fiberglass attic can be air sealed as well as a sprayfoam attic

Draped vs Boxed Netting

Thermal Performance with the same average thickness of 7.5”

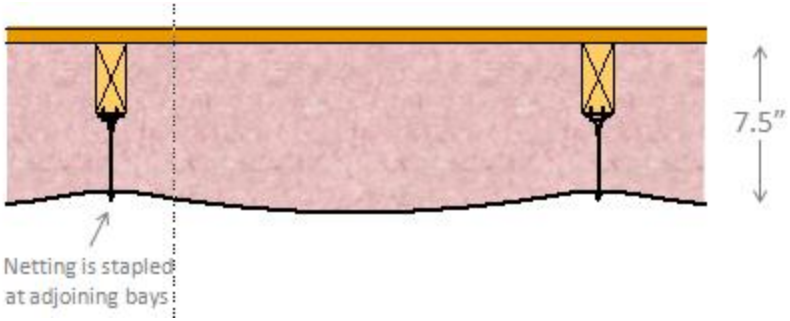
Thermal Performance

- Draped Netting



- U-value = 0.044
- Truss cords exposed to attic – thermal bridge and cold spot (condensation)

- Boxed Netting



- U-value = 0.033
  25% better
- Permits future vapor permeance tuned netting for controlling truss cord moisture

Box Netting- evolved Wolf/Walden/Salonvaara

Conclusions

Summary:

1. Unvented Attic design # 1 (Drapped systems) has demonstrated outstanding performance for a full year of monitoring.

2. Fiberglass is a cost effective solution with excellent performance.

3. No risk was found for the hygrothermal performance of the unvented attic

4. Fiberglass is non-flammable, non VOC and mold resistant

5. Box netting results in superior thermal & moisture performance