



Environmental Energy Technologies Division Lawrence Berkeley National Laboratory

# Accelerated Aging of Roofing Materials (the “Advanced Surfaces” project)

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CRRC Membership Meeting  
Reno Nevada  
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U.S. DEPARTMENT OF  
**ENERGY** | Energy Efficiency &  
Renewable Energy

Building Technologies Program

# “Advanced Surfaces” Team

## LBL team



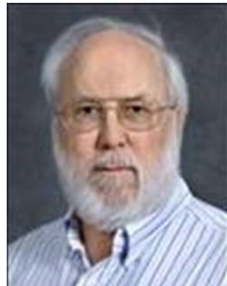
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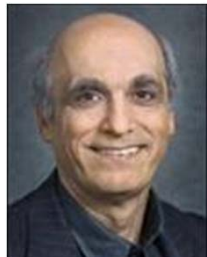


Haley Gilbert



Mike Spears

## Concordia University



Hashem Akbari

## ORNL



Andre Desjarlais



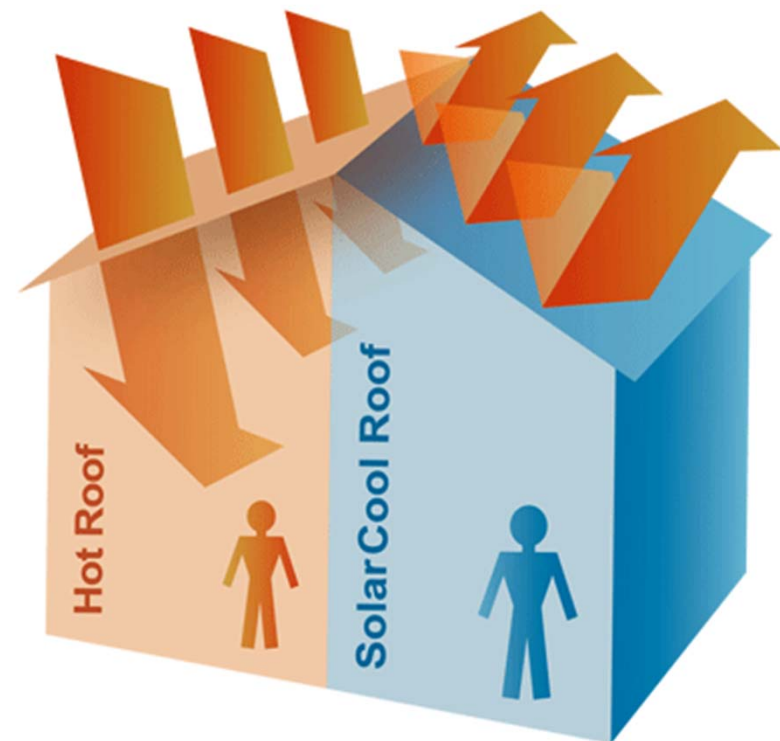
Bill Miller



# Cool roofs

Replacing a dark roof with a cool (highly reflective) roof can

- ✓ Reduce annual cooling energy use by 5-20%  
(*Levinson et al. 2005*)
- ✓ Lower the outside air temperature and the rate of smog formation  
(*Rosenfeld et al. 1998; Akbari et al. 2001*)
- ✓ Delay global warming (10 tonnes of CO<sub>2</sub> offset by 100 m<sup>2</sup> of white roofing)  
(*Menon et al. 2010; Akbari et al. 2009; Oleson et al. 2010*)



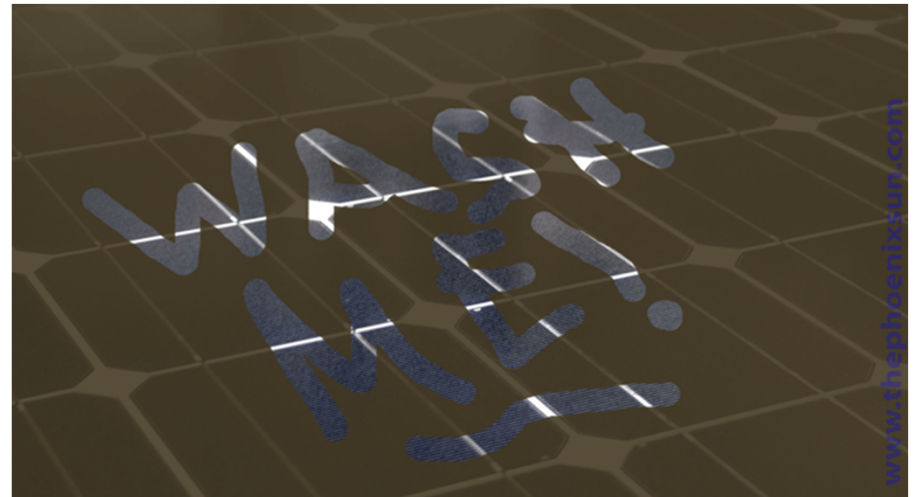
# Overview

## MOTIVATION

- Advance the production and adoption of high-performance, soiling-resistant roofing products

## OBJECTIVES

- Create an accelerated soiling and weathering method for roofs and PVs
- Develop international standards for accelerated exposure
- Learn how to make roofs and PVs stay clean



# Background

- Recent ORNL/LBNL work on soiling of inert PVDF coatings in California
  - Weak soil adhesion leads to clean materials after rain
  - Dusty summers are followed by rainy winters
  - Solar reflectance varies with the season
- Weathering of asphalt shingles
  - Material changes in first year increase reflectance
  - Changes thereafter just due to soiling



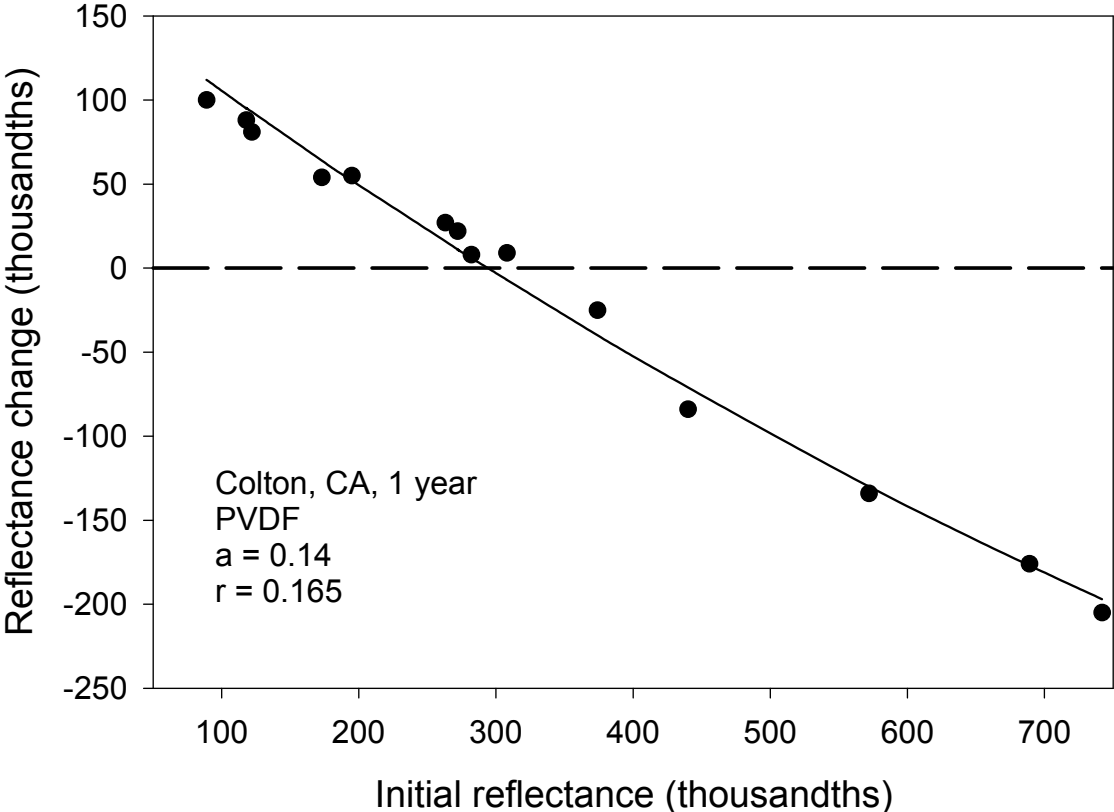
# PVDF white sample at Shafter, CA at 1 year (August)



# Soiling reduces reflectance of light surfaces and increases the reflectance of dark surfaces

(ORNL / LBNL California study)

[Here the parameters  $a$  and  $r$  are the solar absorptance and solar reflectance of the soil layer.]



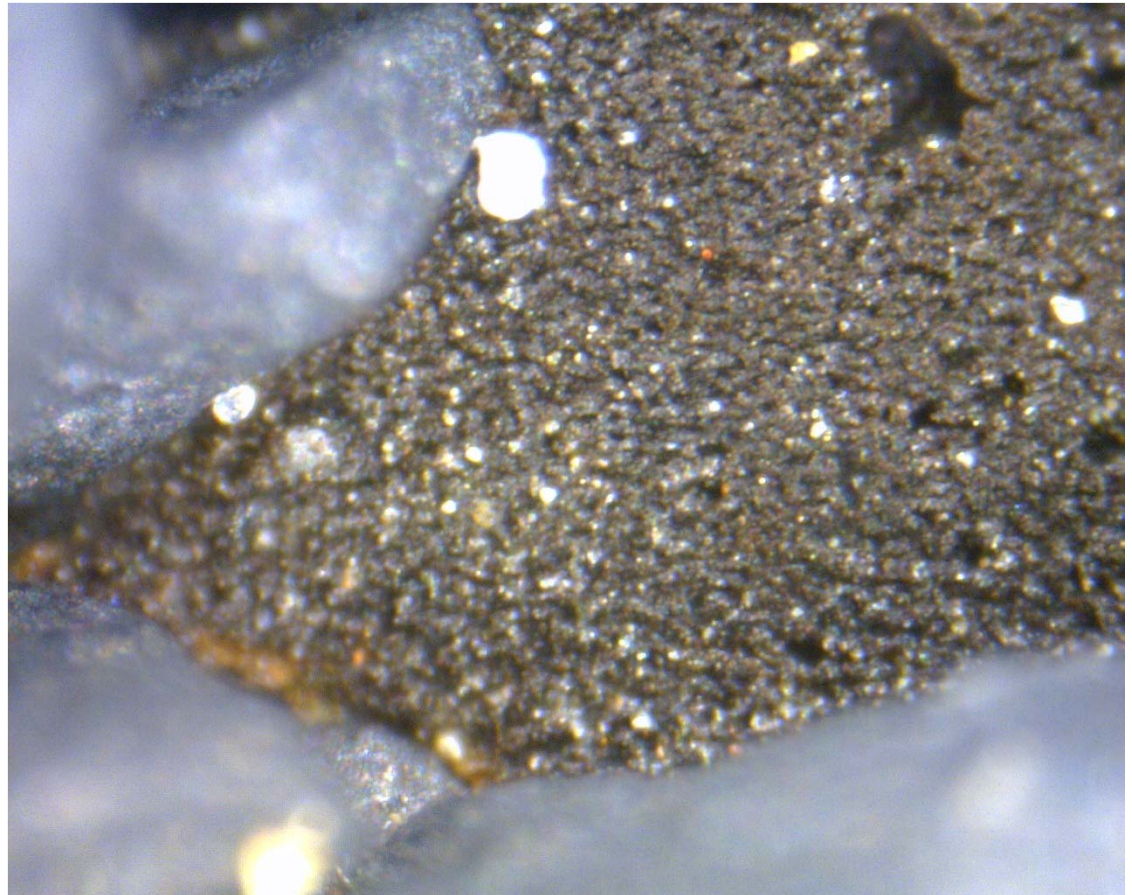
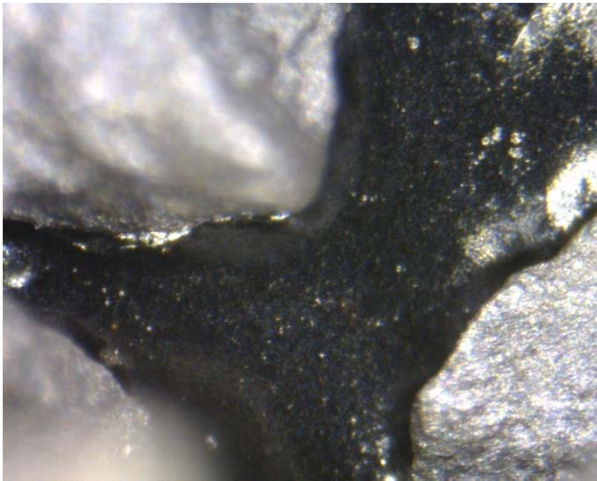
# Soiling reduces reflectance ... continued

- Zero crossing occurs at  $R^* = 0.2$  to  $0.4$ 
  - Brightness of local soil
  - Largest values in southern desert
- PVDF accumulates less soil than tile due to reduced adhesion
- Steeper tilt - less soil
- More soil/dust in dry southern California
- Seasonal pattern of dusty summers and wet winters

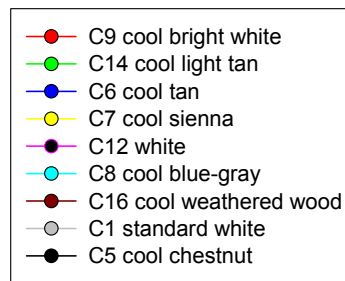
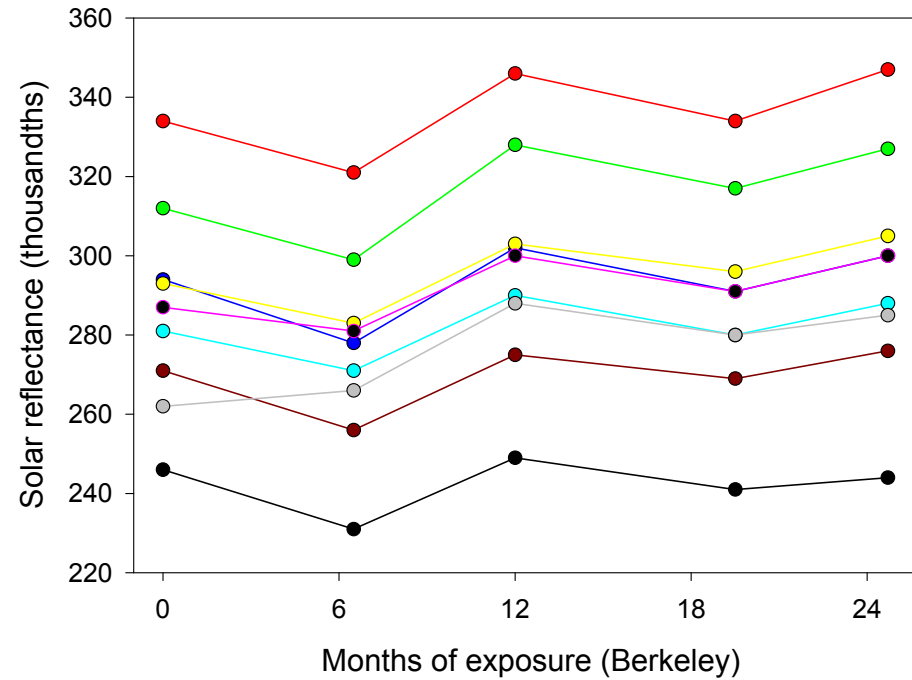
# Close up of unweathered and weathered shingles



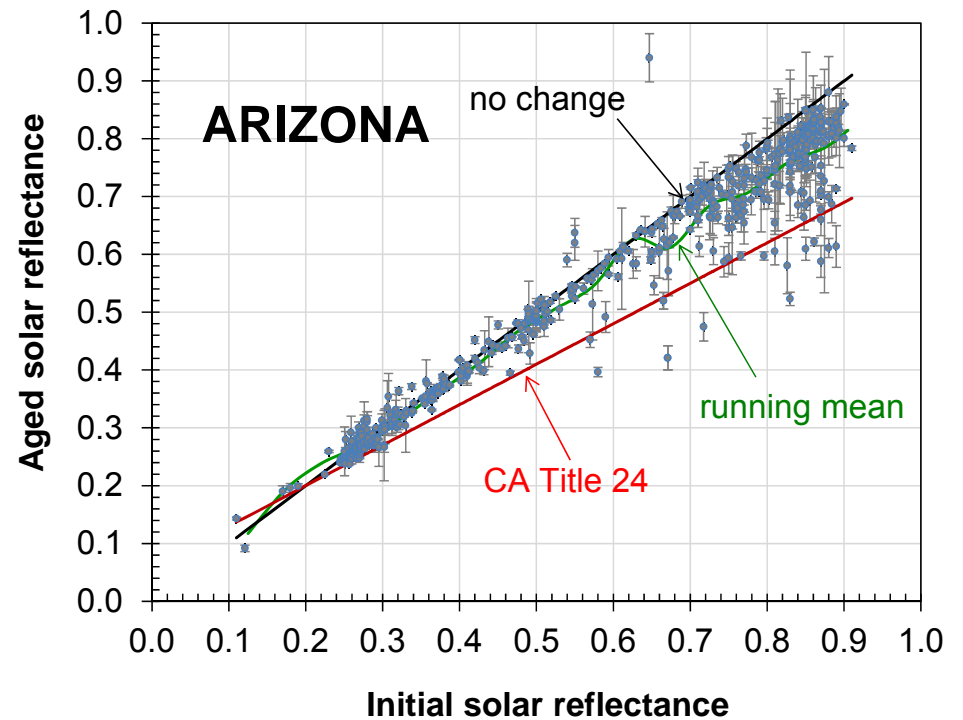
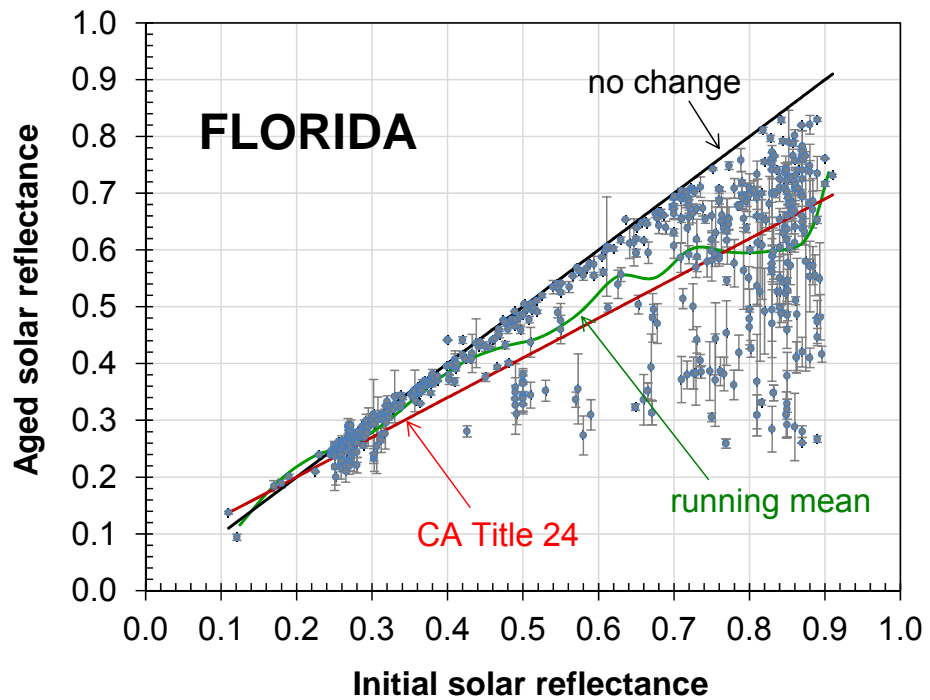
# Asphalt on black shingle new (left) and weathered (right)



# Reflectance of 8 reflective asphalt shingle panels, beginning spring, 2008



# Effect of aging on solar reflectance (i/ii)



- California Title 24 provisional aged solar reflectance formula:

$$\rho'_{a,T24} \equiv 0.20 + 0.70(\rho_i - 0.20)$$

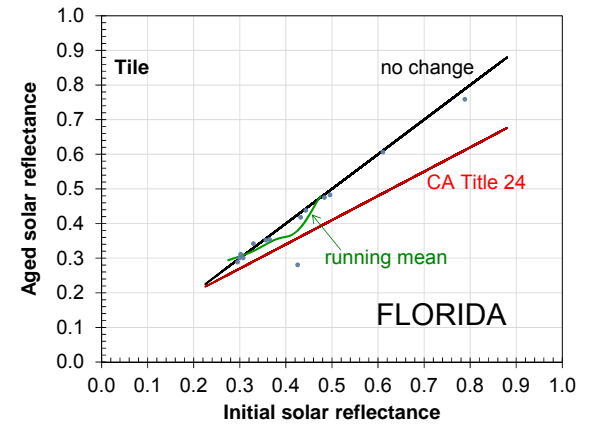
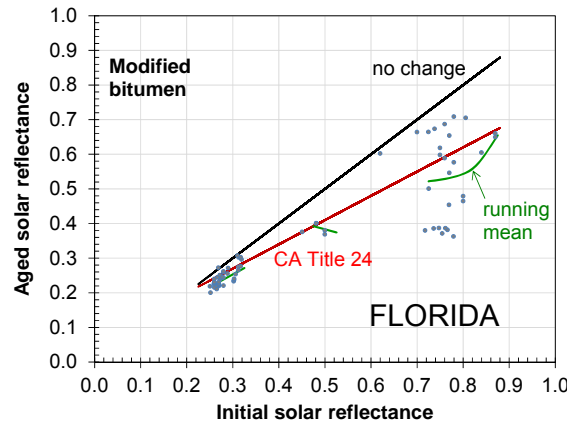
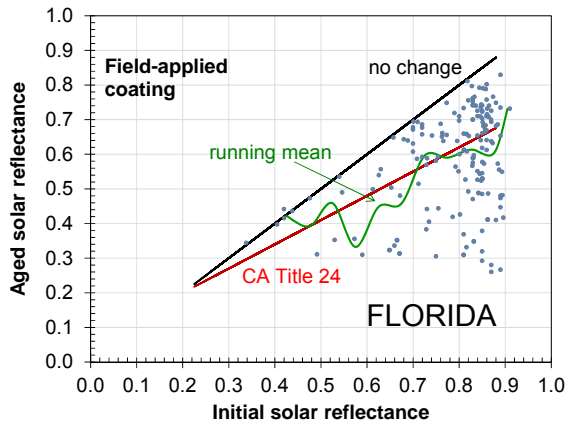
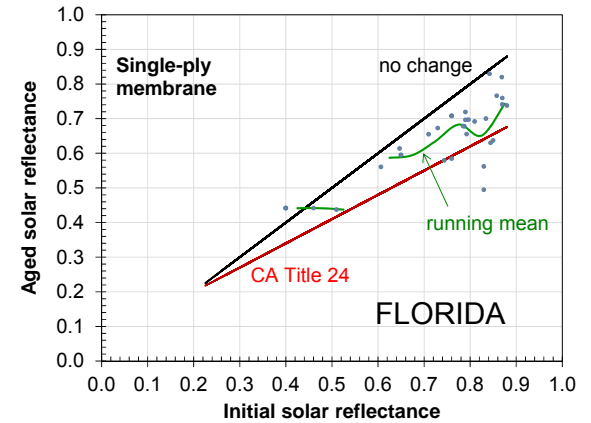
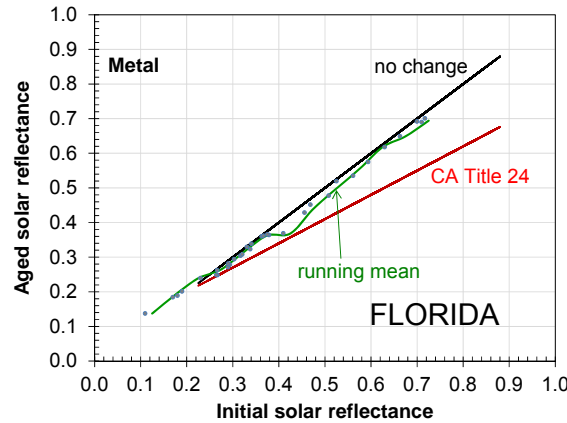
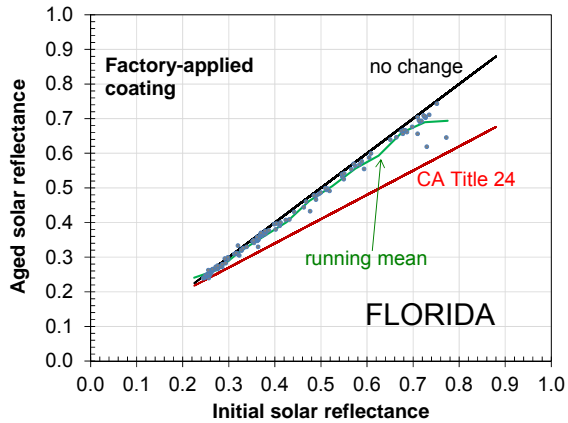
SR of an opaque soil layer

resistance to soiling

Initial SR



# Effect of aging on solar reflectance (ii/ii)



# Roofing products used in our study

- ❑ We screened 100 roofing materials from 40 suppliers
- ❑ Selection of different materials:

- ✓ Asphalt shingles
- ✓ Concrete tiles
- ✓ Clay tiles
- ✓ Single-ply membrane
- ✓ Metal roofing
- ✓ Factory applied coatings
- ✓ Field applied coatings

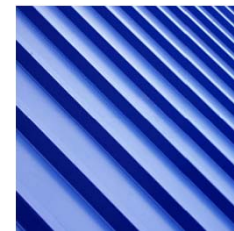
shingles



concrete tiles



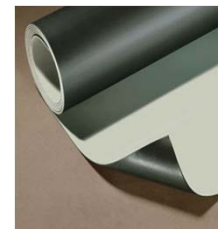
metal roofing



clay tiles



single-ply membrane



coatings

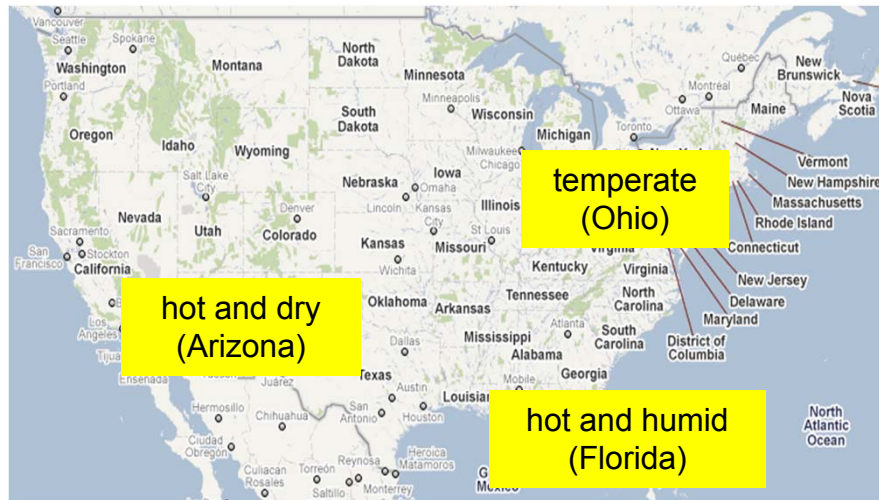


- ❑ Selection criteria included diversity of products & colors, market presence, sample uniformity and availability of aged samples



# Natural weathering of roofing products

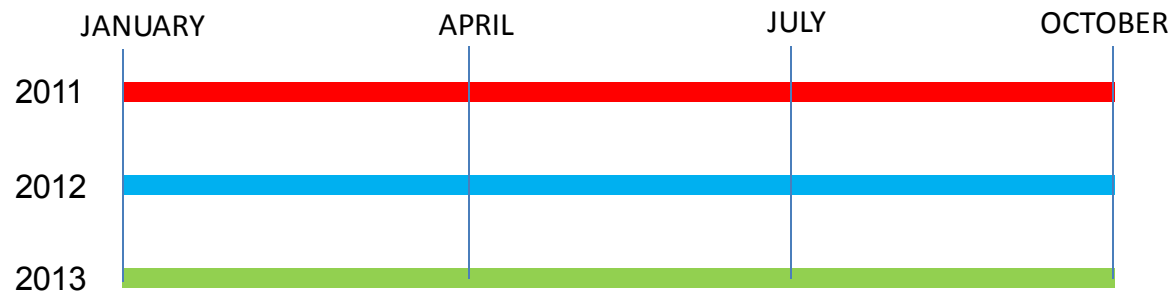
- ☐ Samples naturally aged at 3 weathering sites



Florida



- ☐ Samples collected and characterized quarterly

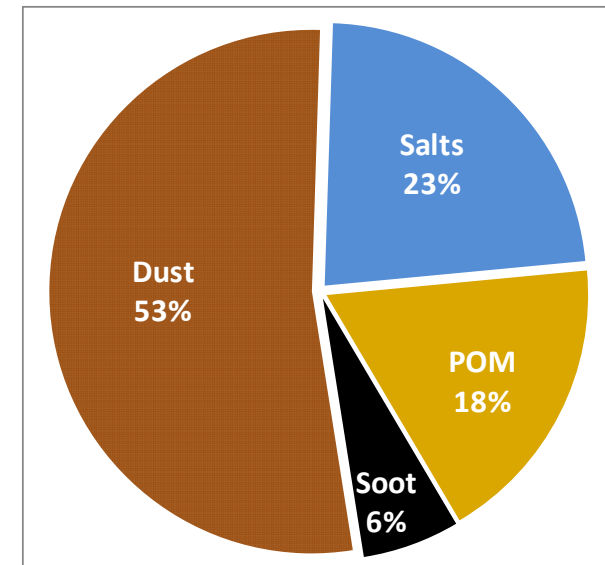


# Laboratory accelerated soiling tests

## Outline:

1. Develop spraying system for application of soiling agents
2. Test with soot, salts, organic matter and dust surrogates
3. Compare deposition of soiling constituents on roofing materials
4. Validate by comparing with naturally aged samples
5. Validate by comparing with roadway tunnel-soiled samples

Average composition (in mass) of soiling components from atmospheric deposition



**Dust** 28 – 66%    **Salts** 18 – 27%    **POM** 8 – 36%    **Soot** 4 – 12%

POM: Particulate Organic Matter

*Favez et al, 2006 – Atmos. Environ*



# Soiling surrogates prepared in our lab



**Salts**



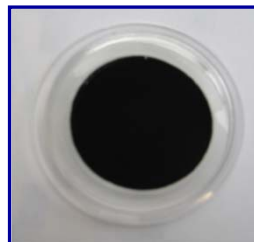
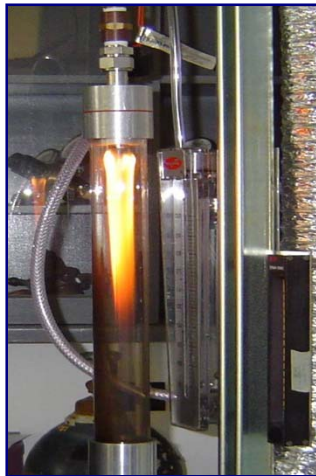
**Organics**



**Dust**



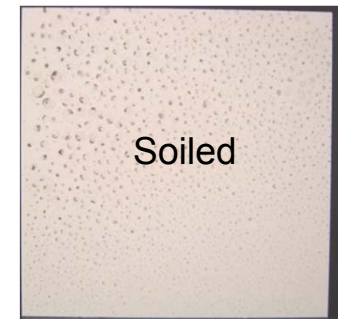
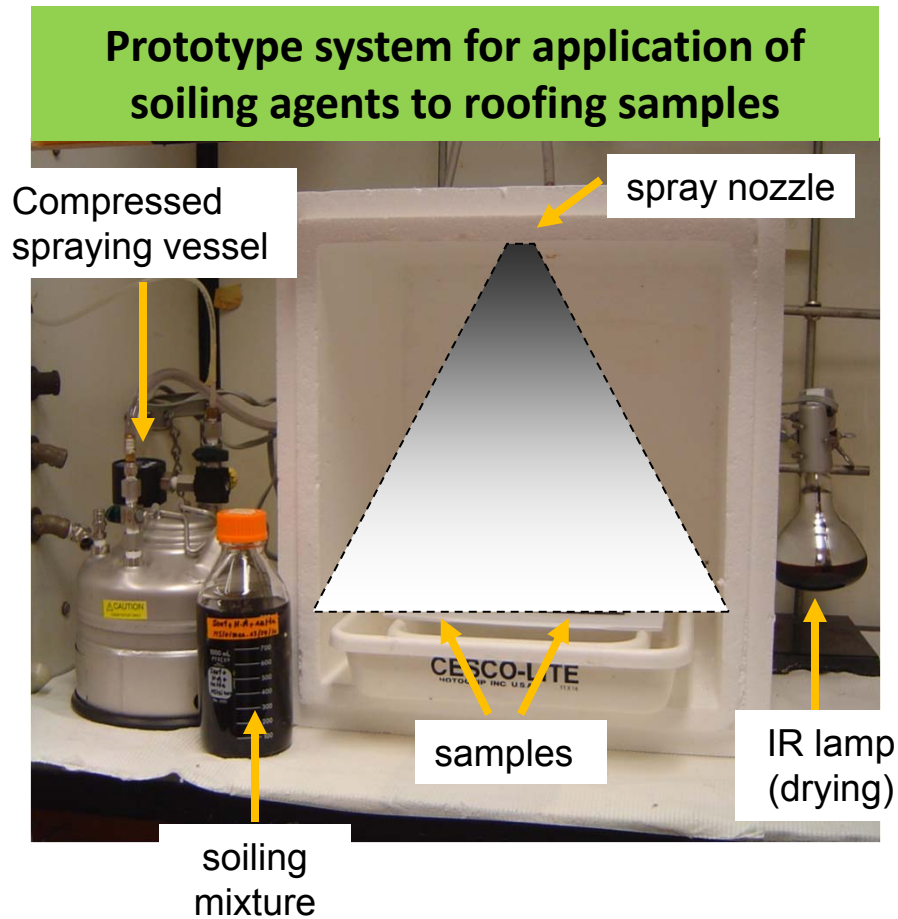
**Soot hydrosol**



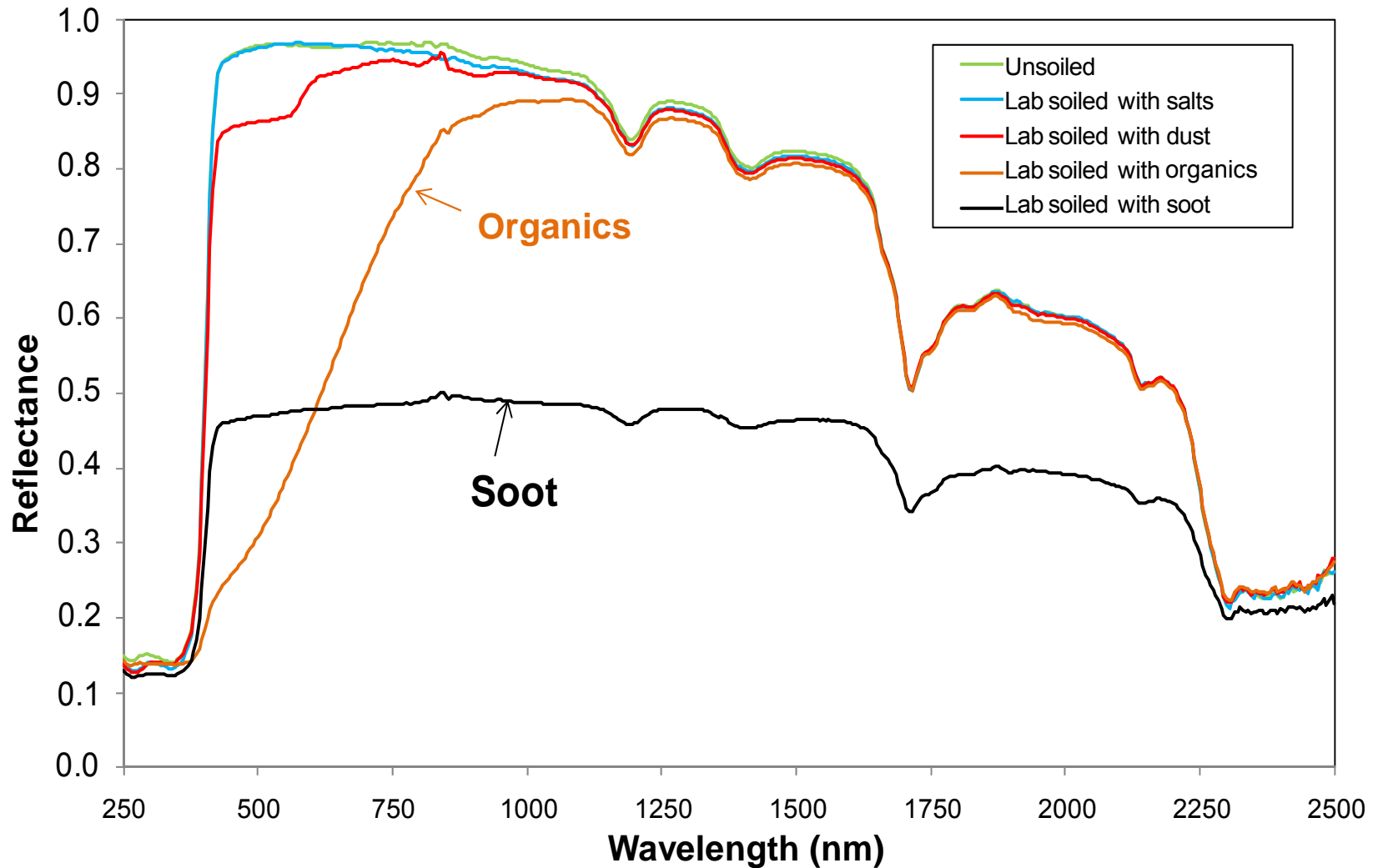
**Ozone**



# Accelerated aging at LBNL



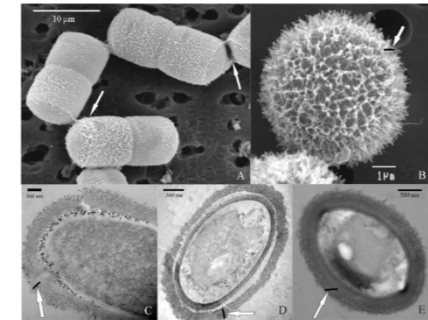
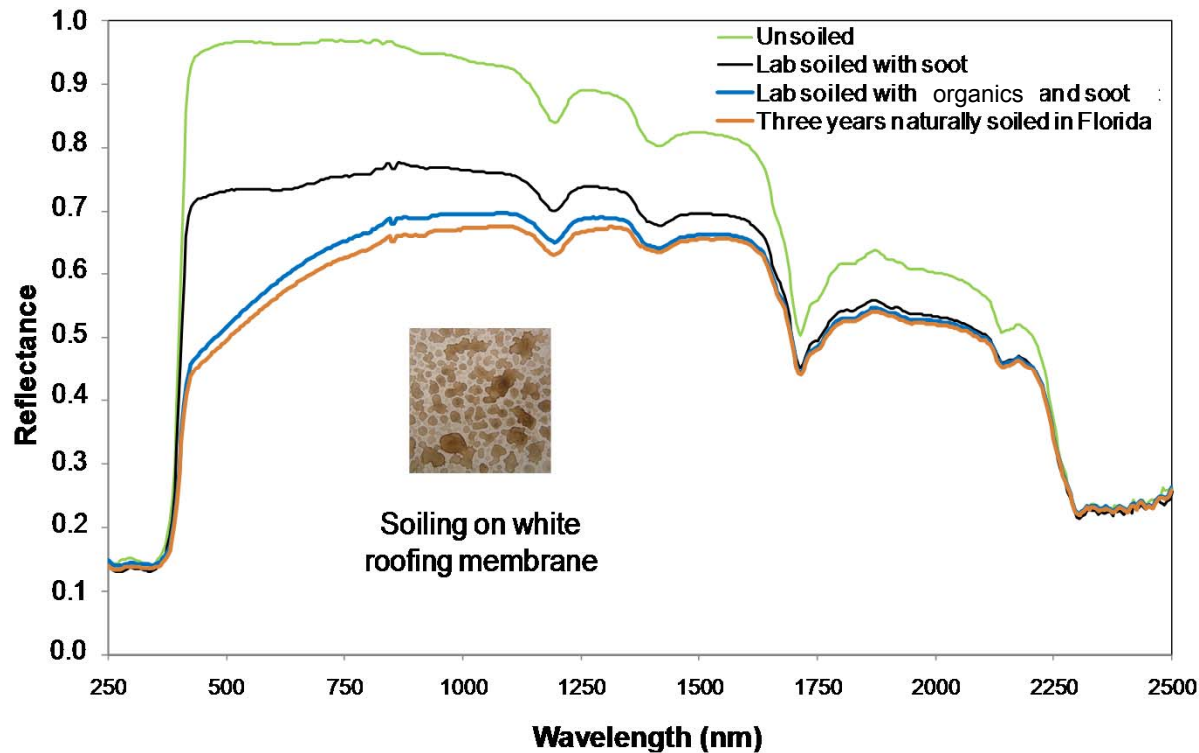
# Effect of each soiling constituent on SR



# Optimization of soiling mixture to mimic soiling of roofing products in hot & humid climate

Very good match between our lab soiled (1 min) and 3 years aged roofing membrane in Florida

Can organics mimic microbiological growth?



# Summary

- ❑ Developing reliable approach for accelerated soiling of roofing materials
  - ✓ Good correlation between the loading of soiling constituents and the loss of solar reflectance ( $\rho_a/\rho_i$ )
  - ✓ Tunable to mimic soiling in dry, temperate, hot & humid climates
  - ✓ Validated with naturally aged and tunnel-soiled samples in preliminary tests (further validation underway)
  - ✓ Straightforward method that can be readily adopted by industry
- ❑ Established a large network of industrial collaborators and other stakeholders to support implementation



# Ongoing work

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- Integrate laboratory weathering and soiling
- Examine seasonal effects in natural weathering
- Validate our laboratory process with naturally aged samples
- Form new ASTM, ISO task groups
- Convene summer 2011 workshop at LBNL to build momentum for soiling standard
- CRADA with Dow Chemical





## Workshop on Advances in Cool Roof Research: Protocols, Standards & Policies for Accelerated Aging



Thursday, July 28 –  
Friday, July 29, 2011  
Berkeley, California USA

<http://coolroofs2011.lbl.gov>

### Agenda

- Accelerated soiling and weathering of roofing materials
- Incorporation of accelerated aged ratings into policies, standards and rating systems
- Benefits of soiling- and weathering-resistant cool urban surfaces
- Development of next generation cool roofing (and pavement)
- Marketplace trends in cool roofing

### Intended audience

- Roofing industry
- Weathering firms
- US DOE, US EPA, CEC, CARB
- US CRRC, EU Cool Roof Council, international rating bodies (e.g., China, India, Japan)
- ASTM, ASHRAE, ISO, US Green Building Council
- Utilities and other stakeholders



# CRADA with ORNL and Dow Chemical

- ❑ **Goal:** facilitate development of advanced elastomeric coating technology
- ❑ **Target:** 75% aged solar reflectance, boosting energy savings by 50%
- ❑ **DOW** will develop new polymers and coating formulations
- ❑ **ORNL/LBNL** will evaluate retention of solar reflectance in natural and accelerated aging tests



# Acknowledgments

- Funding:
  - U.S. Department of Energy (DOE)
    - Program Manager: Marc LaFrance
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- Experiments and measurements
  - David Francois
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  - Chelsea Preble
  - Mike Spears
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