

White Roofs to Cool your Building, your City and  
(this is new !) Cool the World. A US Progress Report

GSEP Working Group on Cool Roofs & Pavements  
Crystal City, VA, Sept. 12, 2011

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Presentation available at [www.ArtRosenfeld.org](http://www.ArtRosenfeld.org)

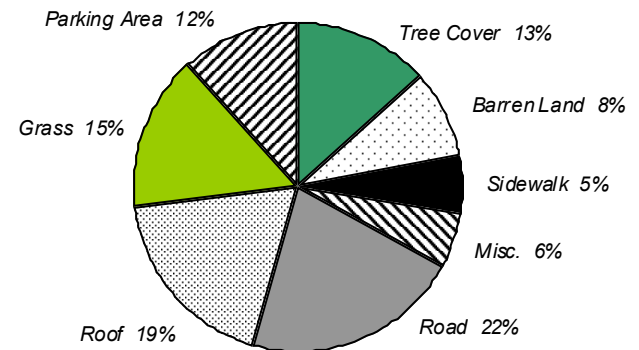
Filename GSEP Workinh Group fmAccel Aging, fm EESI DC fm Blum Center from Russian  
Talk 6-5-11 + DR from EE Summit Sactp. . Path DinnerTalk Life at CEC. ARPA-E

# Bird's eye view of urban land use



The surface of Sacramento, CA is about

- **20% roofs**
- **30% vegetation**
- **40% pavement**



Area by Land-Cover Category Above the Canopy

~ 1 km<sup>2</sup>

# Chicago Heat Wave 1995, 739 Deaths

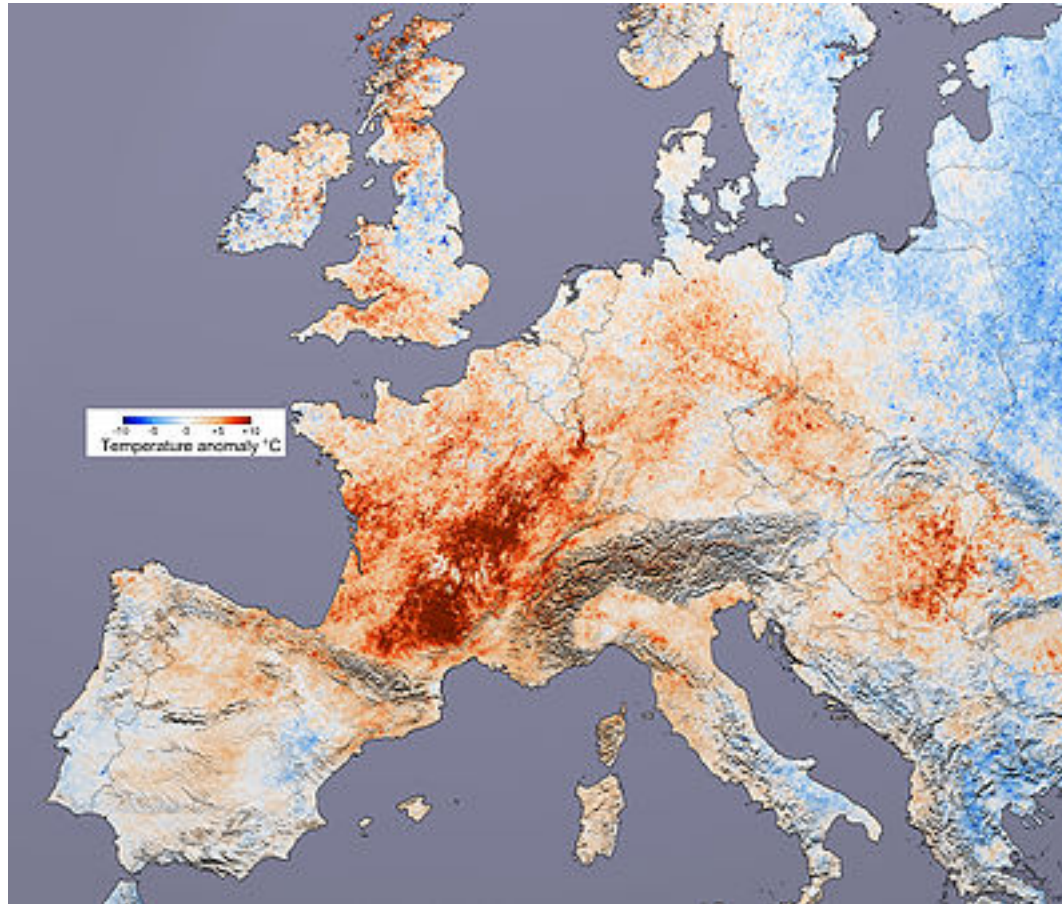
The highest risk group lived on  
the top floors of buildings with black roofs





# European Heat Wave 2003, 30,000 Deaths

## Moscow-Centered Heat Wave 2010, ~10,000 Deaths



White roofs around the world

...in Santorini, Greece





...in Hyderabad, India



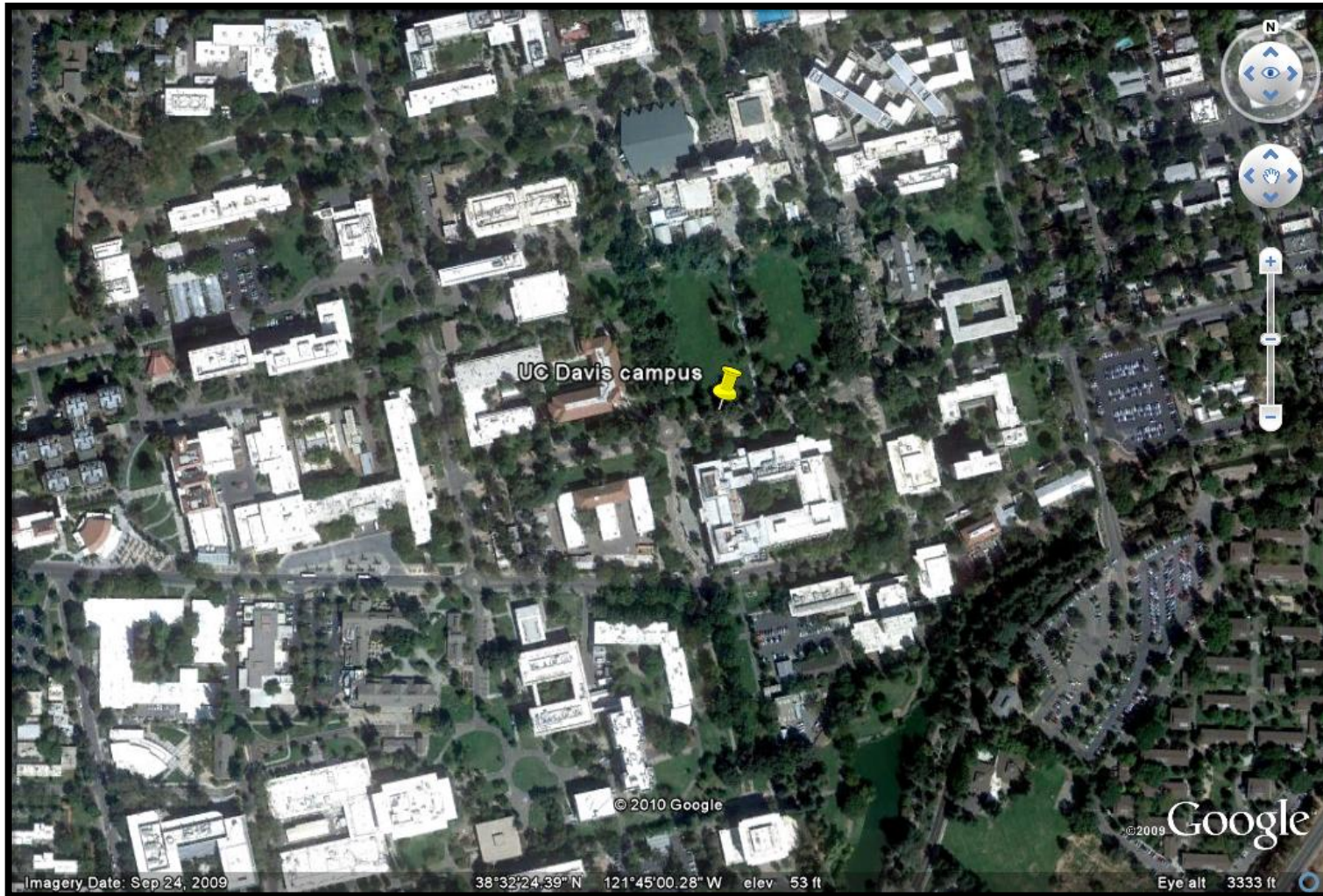
**...and widely  
in the state of  
Gujarat, India.**

# Walmart store in northern California, ~2005



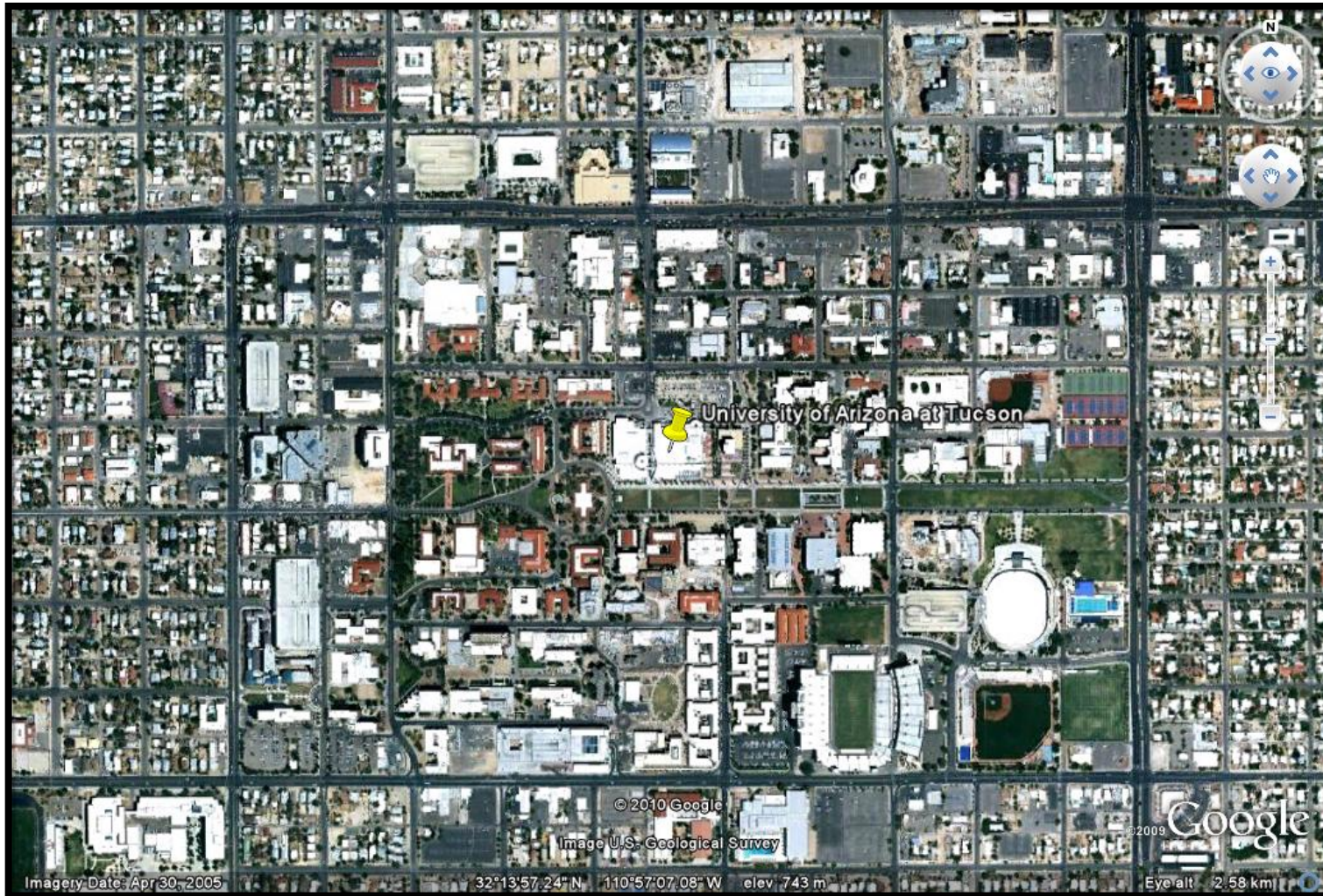


# Congratulations to UC Davis



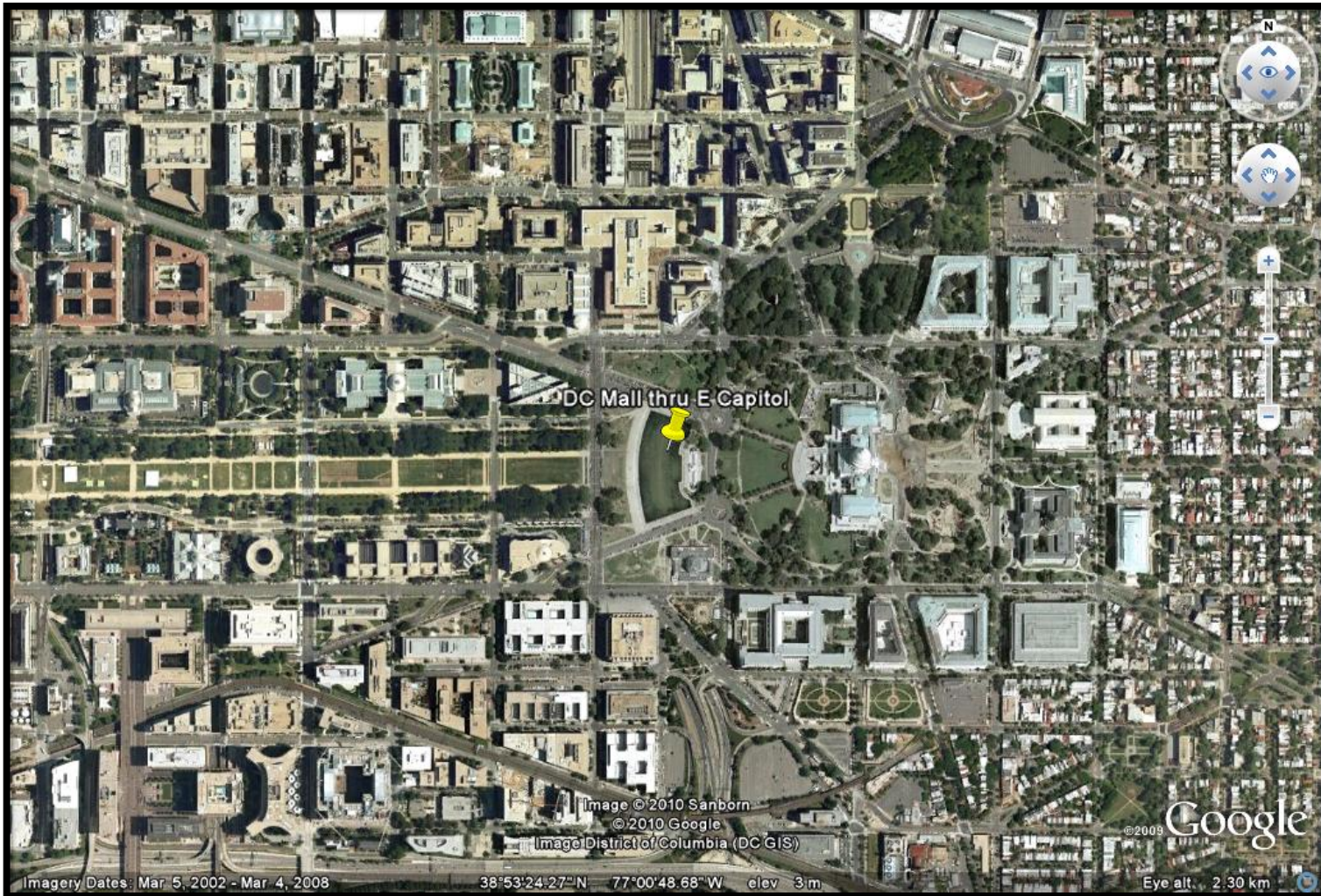


# White roofs are popular in Tucson, AZ





# Washington, DC (Federal) has problems





# Pentagon



Electromagnetic Spectrum—  
Reflected Sunlight Escapes, but Heat  
(degraded sunlight) is trapped by the  
Greenhouse Effect

# Reference Book

Consider a Spherical Cow

(A Course in Environmental Problem Solving)

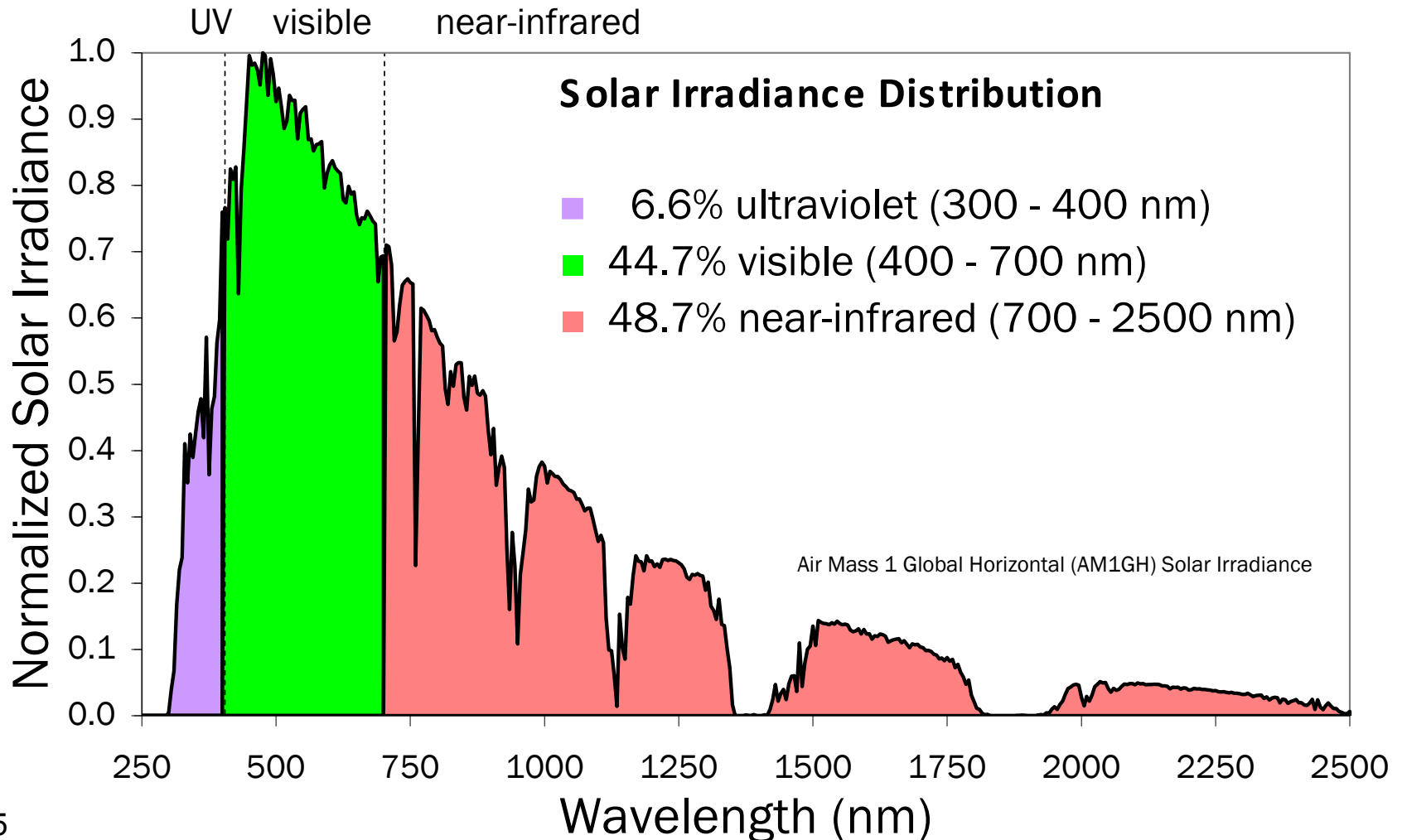
By John Harte, UC Berkeley

University Science Books, Mill Valley, CA 1988

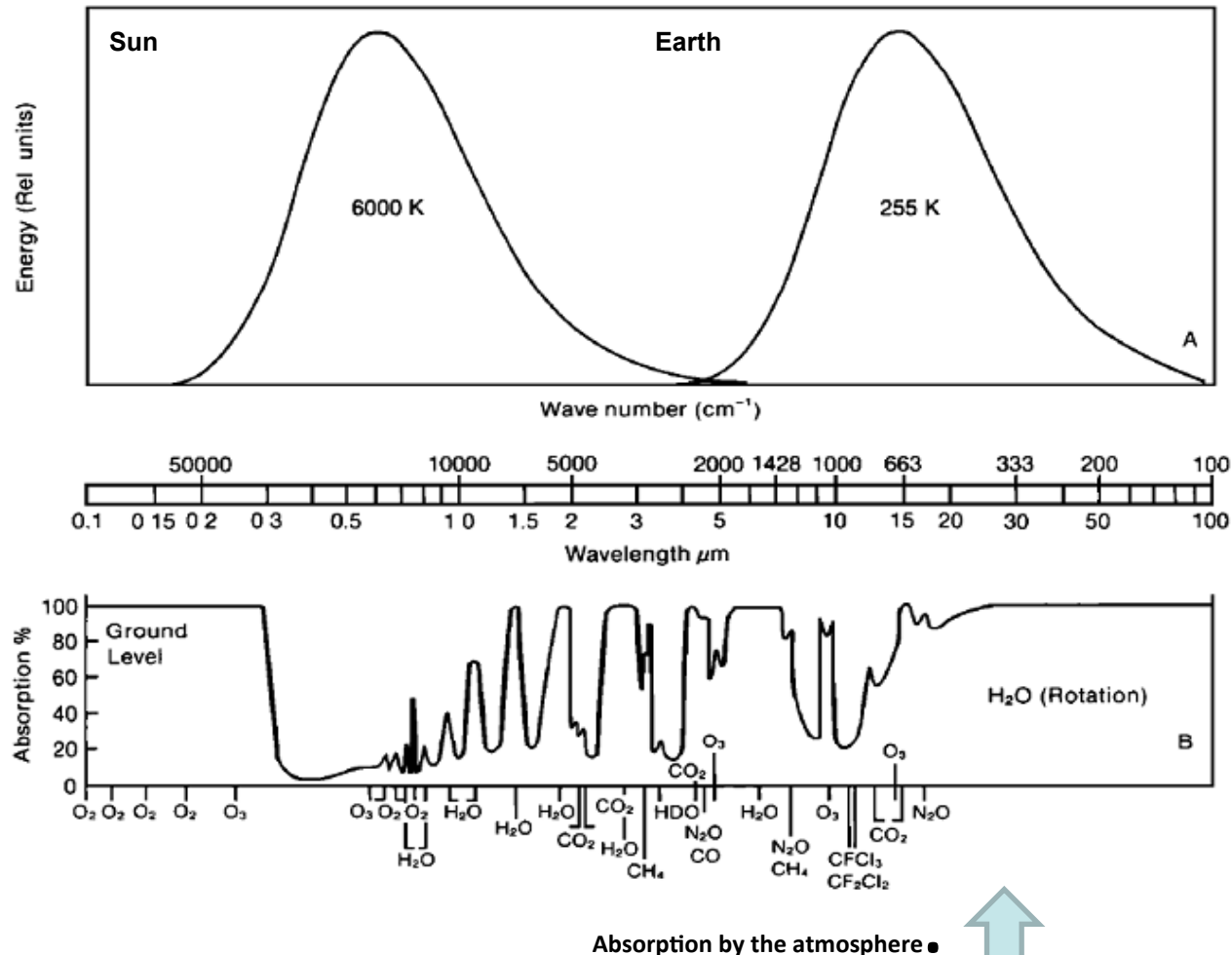
Urban Heat Islands Ch3.B.9



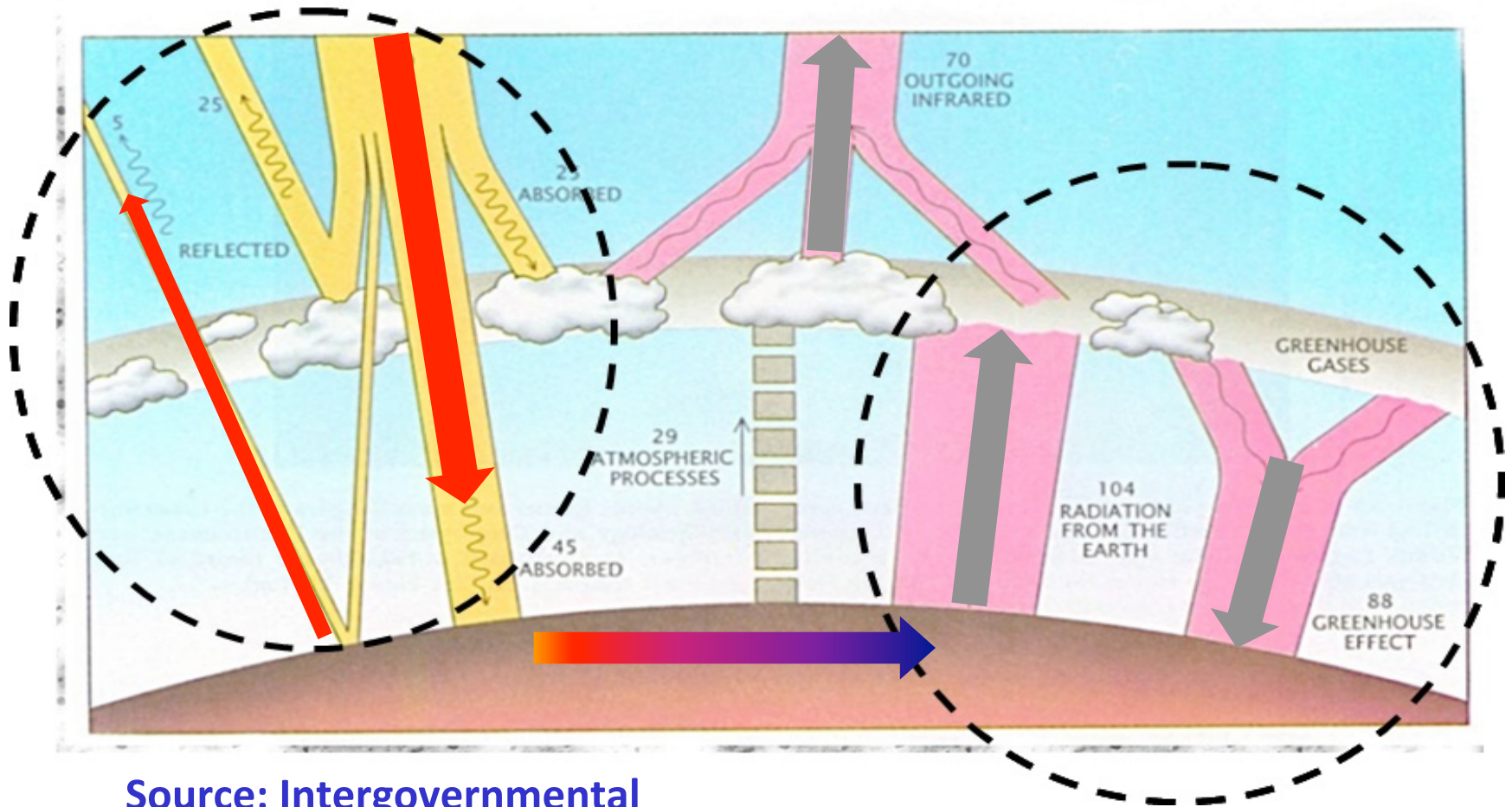
# Sunlight — more than meets the eye



# Atmospheric greenhouse effect (i/ii)



# Solar-reflective surfaces cool the globe via “negative radiative forcing”



Source: Intergovernmental  
Panel on Climate Change (IPCC)



Cool, reflective  
surfaces “offset” the  
heating effect of CO<sub>2</sub>  
emitted into the  
atmosphere

**GLOBAL COOLING:** 100 m<sup>2</sup> (1000 ft<sup>2</sup>) of white roof replacing grey offsets the **emission** of 10 t of CO<sub>2</sub>



How much CO<sub>2</sub> equivalent is offset if we whiten all eligible urban flat roofs worldwide? (i/ii)

- Answer: **24 Gigatonnes (Gt)**
  - 2/3 of a year's worldwide emission
  - Gigatonne = billion metric tons
- If implemented over 20 years (the life of a roof or a program) this is  $\approx$  1.2 Gt/year.



# How much CO<sub>2</sub> equivalent is offset if we whiten all eligible urban flat roofs world-wide? (ii/ii)

- Offset is equivalent to **taking 300 million cars off the road for 20 years.**
  - There are about 600 million passenger cars world wide, and they each emit  $\approx 4 \text{ t CO}_2/\text{year}$ .



# In terms of avoided power plants

Full white roof potential can *offset* the emissions from 500 medium-sized coal fired power plants or 1,000 medium-sized gas fired power plants.

That is just the albedo effect – if the building is air conditioned, it will also avoid comparable *real* CO<sub>2</sub> back at the power plant.

# 3 papers and 1 memo estimate tonnes of CO<sub>2</sub> offset by 100 m<sup>2</sup> (1000 ft<sup>2</sup>) of white roof. May 2010

	Study (available at <a href="http://CoolWhitePlanet.org">CoolWhitePlanet.org</a> )	Method	Cloud cover esti- mation	CO <sub>2</sub> offset (atmos- pheric) per 100 m <sup>2</sup>	CO <sub>2</sub> offset (emitted) per 100 m <sup>2</sup>	World-wide potential CO <sub>2</sub> offset (emitted) from cool roofs	CO <sub>2</sub> offset compared to Akbari et al. 2009
1	Akbari et al. 2009 (LBNL)	calculation	~ 50%	5.5 t	10 t	24 Gt	100%
2	Menon et al. 2010 (LBNL)	GCM + land use model (summer only)	GCM	7 t	13 t	30 Gt	130%
3	Oleson et al. 2010 (NCAR) [CO <sub>2</sub> values from private communication between Oleson & Menon]	GCM + urban canyon model	GCM	7 t	13 t	30 Gt	130%
4	VanCuren et al. 2010 (CARB)	measured solar radiation	not needed	3 t	5 t	Addresses CA only; coastal CA is foggy.	50%

It is assumed that of 1 tonne of CO<sub>2</sub> *emitted* only 0.55 tonnes remain in the *atmosphere* after one year,  
2. so the *atmospheric* and *emitted* columns are just in the ratio of 0.55/1.

# Corroborations Since 2010

Vancuren, et al. is now refereed and published.

**Franco Cotana, et al., University of Perugia**, will present their **2008** paper at Lawrence Berkeley National Laboratory (LBNL) on July 28<sup>th</sup>, 2011. They estimate **7** tonnes of CO<sub>2</sub> offset per 100 m<sup>2</sup> vs. **10** by Akbari, et al.

***Hear Anna Pisello & Frederico Rossi at lunch Friday.***

**All estimates so far agree within a factor of 2.**

Now we need calculations for **individual regions**.





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# **COOL CITIES, COOL PLANET**

## **What to do now**

# Progress in energy efficiency standards

- In 2005, California's "Title 24" energy efficiency standards prescribed white surfaces for low-sloped roofs on commercial buildings. Several hot states are following. **Also New York City, effective January 2012. Vegetated ("green") roofs are deemed "white."**
- In 2008, California prescribed "cool colored" surfaces for steep residential roofs in its 5 hottest out of 16 climate zones.
- **Other U.S. states & all countries with hot summers should follow.**

# Recent cool roof progress (2005 – 2011)

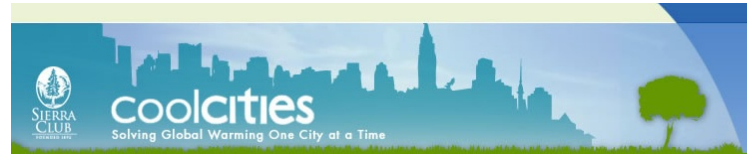
- 2005
  - California Title 24 – “Flat roofs shall be white” (15 out of 16 climate zones). Walmart adopts white roofs for ALL stores.
  - EPA ENERGY STAR lists Cool Roof Materials
- 2010
  - June 1<sup>st</sup>, 2010 – Memo from U.S. Energy Secretary Steven Chu calls for all DOE Buildings to have white roofs, if cost-effective
  - June 16<sup>th</sup>, 2010 – Marine Corp follows suit, Pentagon following slowly
  - June 19<sup>th</sup>, 2010 – *RetroFIT Philly* announces winner of “coolest block” contest to white-coat black roofs of row houses.
- 2011
  - 100 Cool Cities launched – see [www.GlobalCoolCitiesAlliance.org](http://www.GlobalCoolCitiesAlliance.org)
  - Spring 2011 – US launched, at annual G20 Energy Ministers meeting, a voluntary Cool Roofs Working Group, and offered technical assistance to developing countries who join early. India, Mexico, Japan, have joined so far.

To come 2012, 2013

- US Model codes will be modified to “prescribe” that “flat roofs shall be white”
  - ASHRAE 90.1(2013) for commercial buildings
  - EECC(2-12) for residential and commercial buildings
- But states and cities still must **adopt** model codes



# Global Cool Cities Alliance could unite many initiatives and trade associations



EMERALD CITIES COLLABORATIVE  
GREEN • FAIR • DEMOCRATIC



American Council for an Energy-Efficient Economy

THE CLIMATE GROUP

# What about “Green” (Vegetated) Roofs?

## ADVANTAGES

- In a rainy summer they cool buildings and cities comparably with white roofs.
- They hold up ~half of storm water.

## » DISADVANTAGES

- Their albedo is only ~20%,so they absorb sunshine, get warm, and then cool by evapo-transpiration. The absorbed heat is trapped by the greenhouse effect and the cooling by evaporation is cancelled within hours or days by the condensation of the water vapor into rain.
- For global cooling they are only one-third as effective as white roofs.
- Their first cost is ~\$15/sq. ft. and may need an irrigation system.
- I support them, but, as a 5% niche, they can be a distraction.

# Resources on the web

- **Art Rosenfeld's website**
  - [ArtRosenfeld.org](http://ArtRosenfeld.org)
- **Cool Colors Project**
  - [CoolColors.LBL.gov](http://CoolColors.LBL.gov)
- **Heat Island Group**
  - [HeatIsland.LBL.gov](http://HeatIsland.LBL.gov)
- **Cool Communities Project**
  - [CoolCommunities.LBL.gov](http://CoolCommunities.LBL.gov)
- **Roof Savings Calculator**
  - [RoofCalc.com](http://RoofCalc.com)
- **Global Cool Cities Alliance**
  - [GlobalCoolCities.org](http://GlobalCoolCities.org)
- **Cool Roof Rating Council**
  - [CoolRoofs.org](http://CoolRoofs.org)
- **Cool California**
  - [CoolCalifornia.org](http://CoolCalifornia.org)
- **EPA Heat Islands**
  - [epa.gov/heatisland](http://epa.gov/heatisland)
- **Energy Star Cool Roofs**
  - [EnergyStar.gov](http://EnergyStar.gov)