# 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

# Bird's eye view of urban land use

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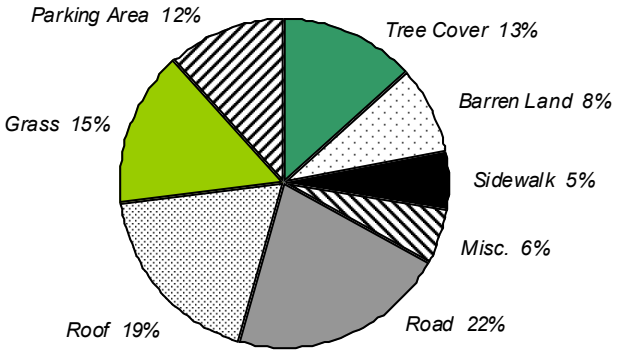
~ 1 km$^2$

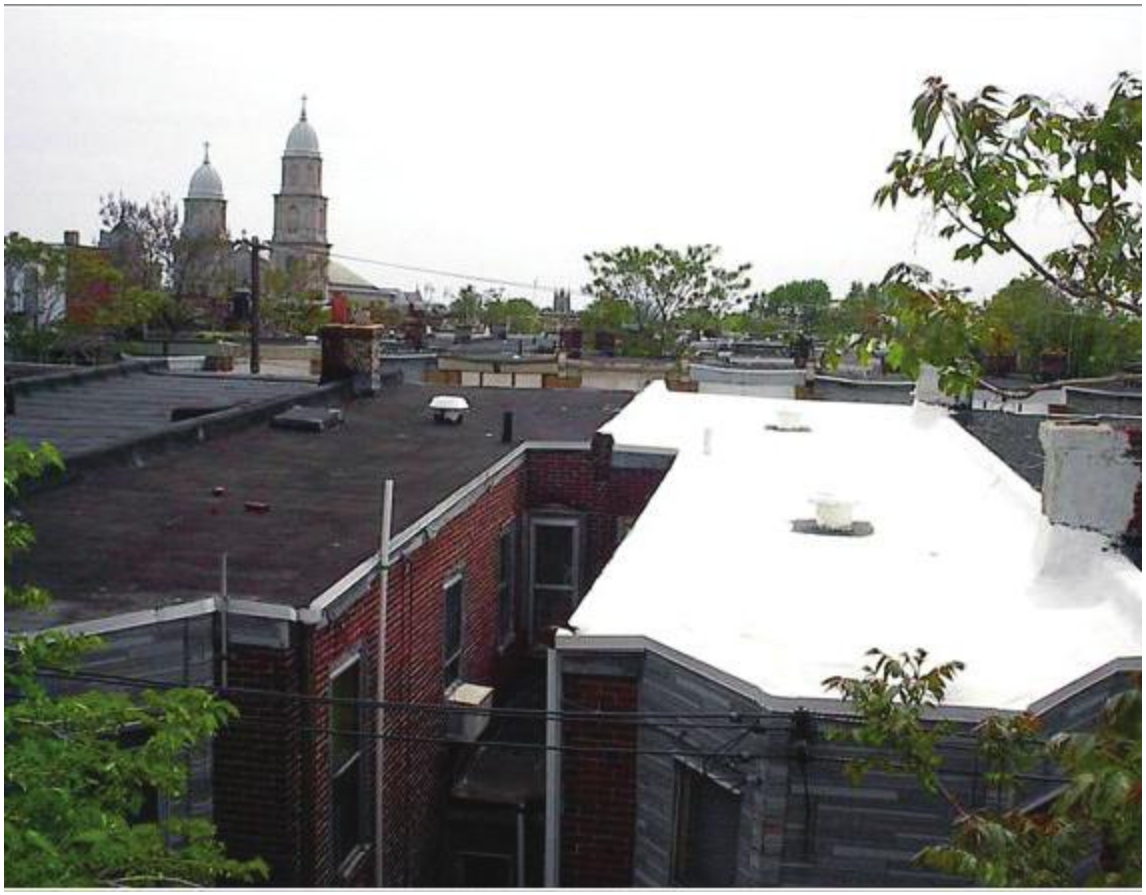
**The surface of Sacramento, CA is about**

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

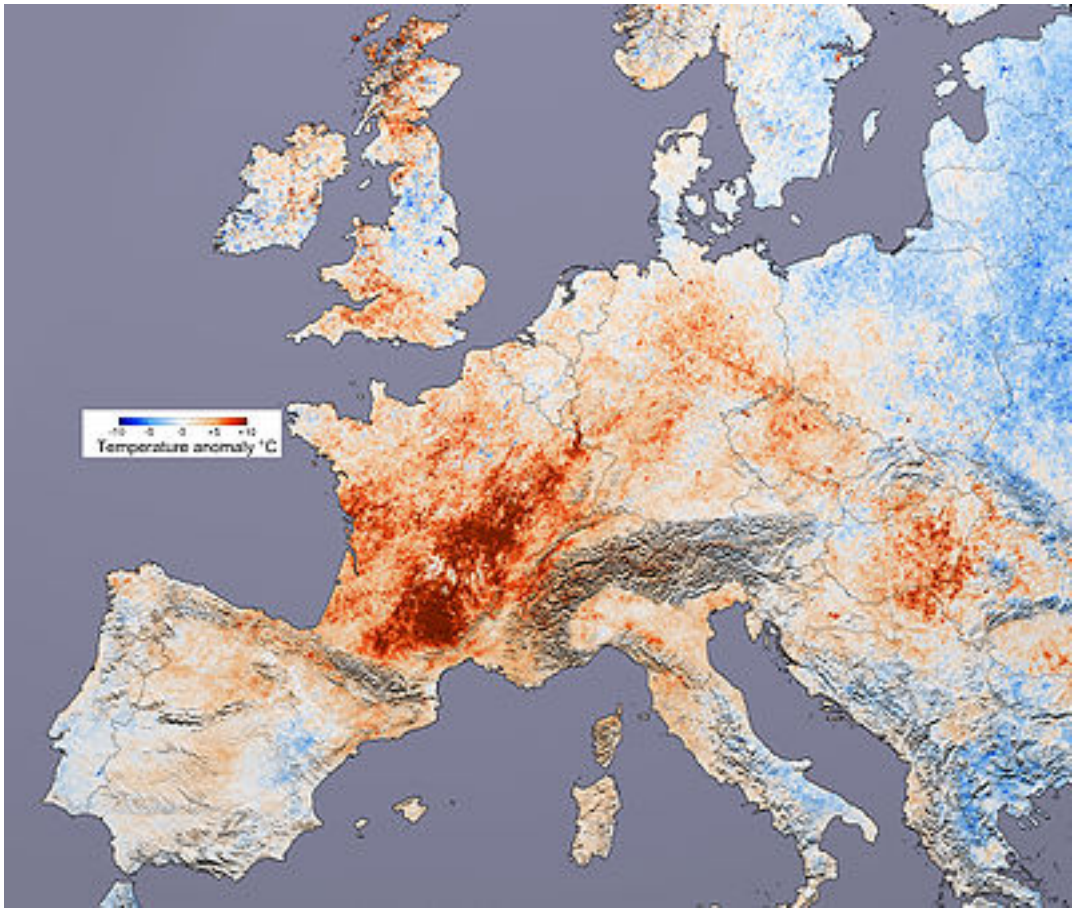



Area by Land-Cover Category Above the Canopy

# 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

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# Congratulations to UC Davis

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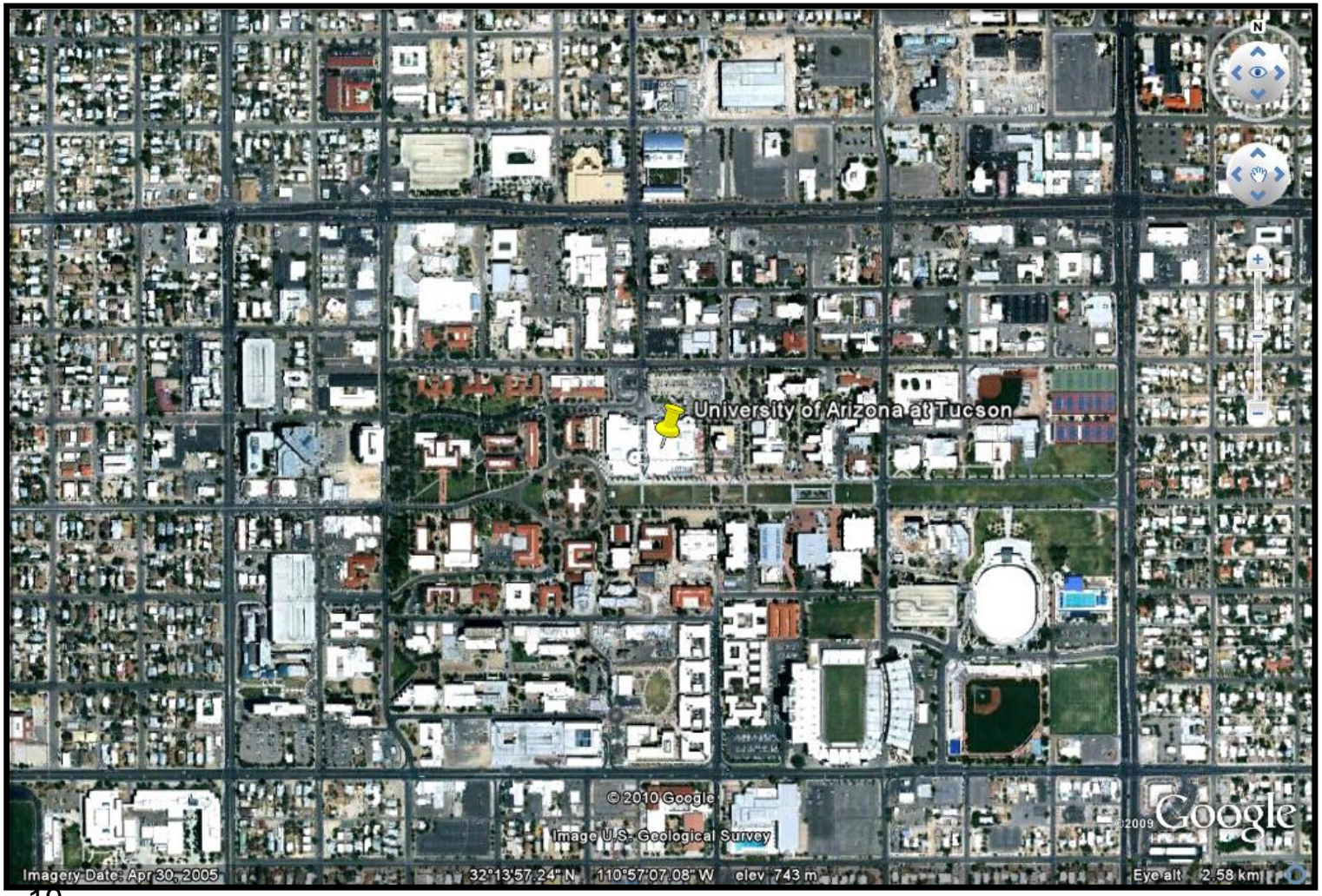
# White roofs are popular in Tucson, AZ



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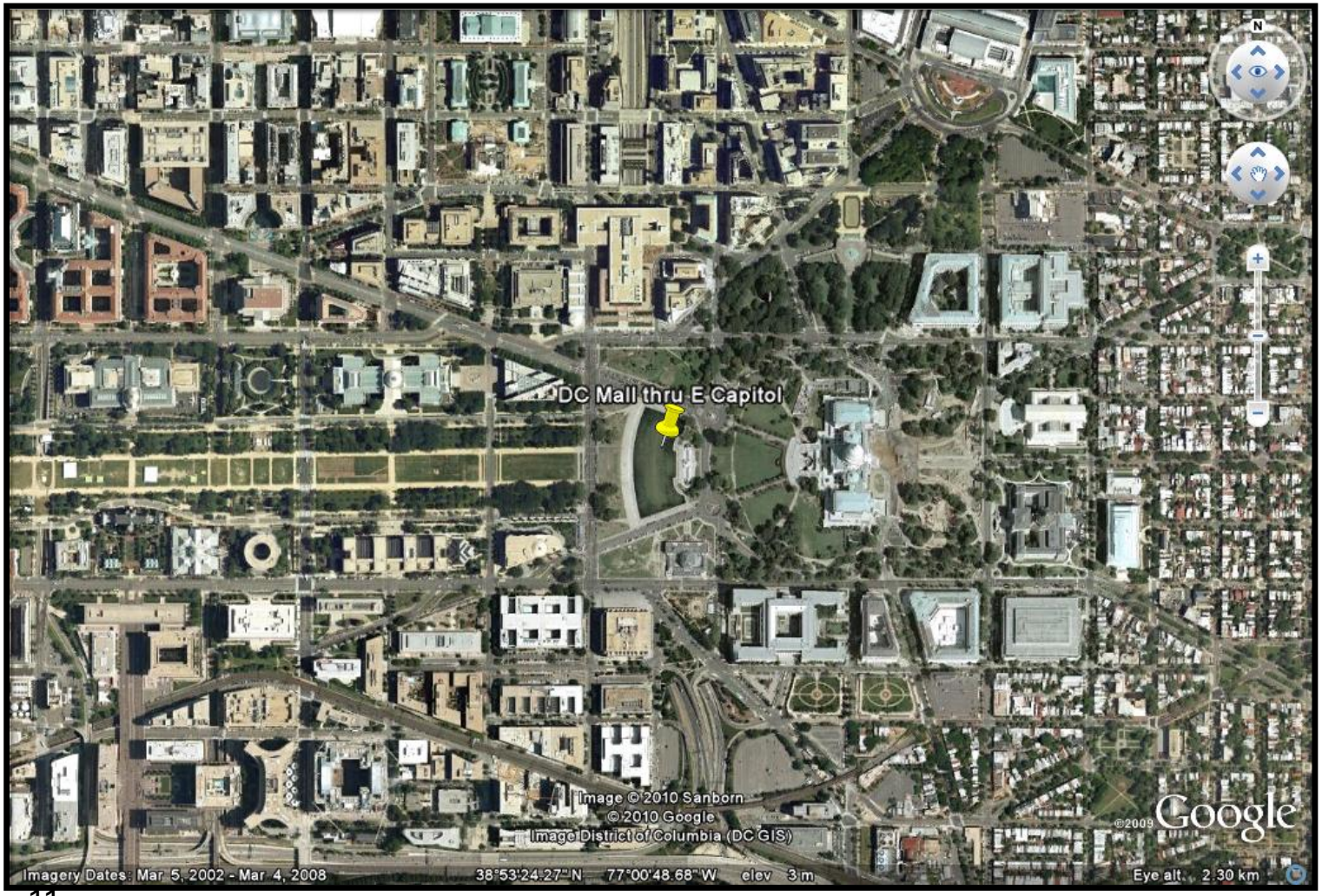
# Washington, DC (Federal) has problems



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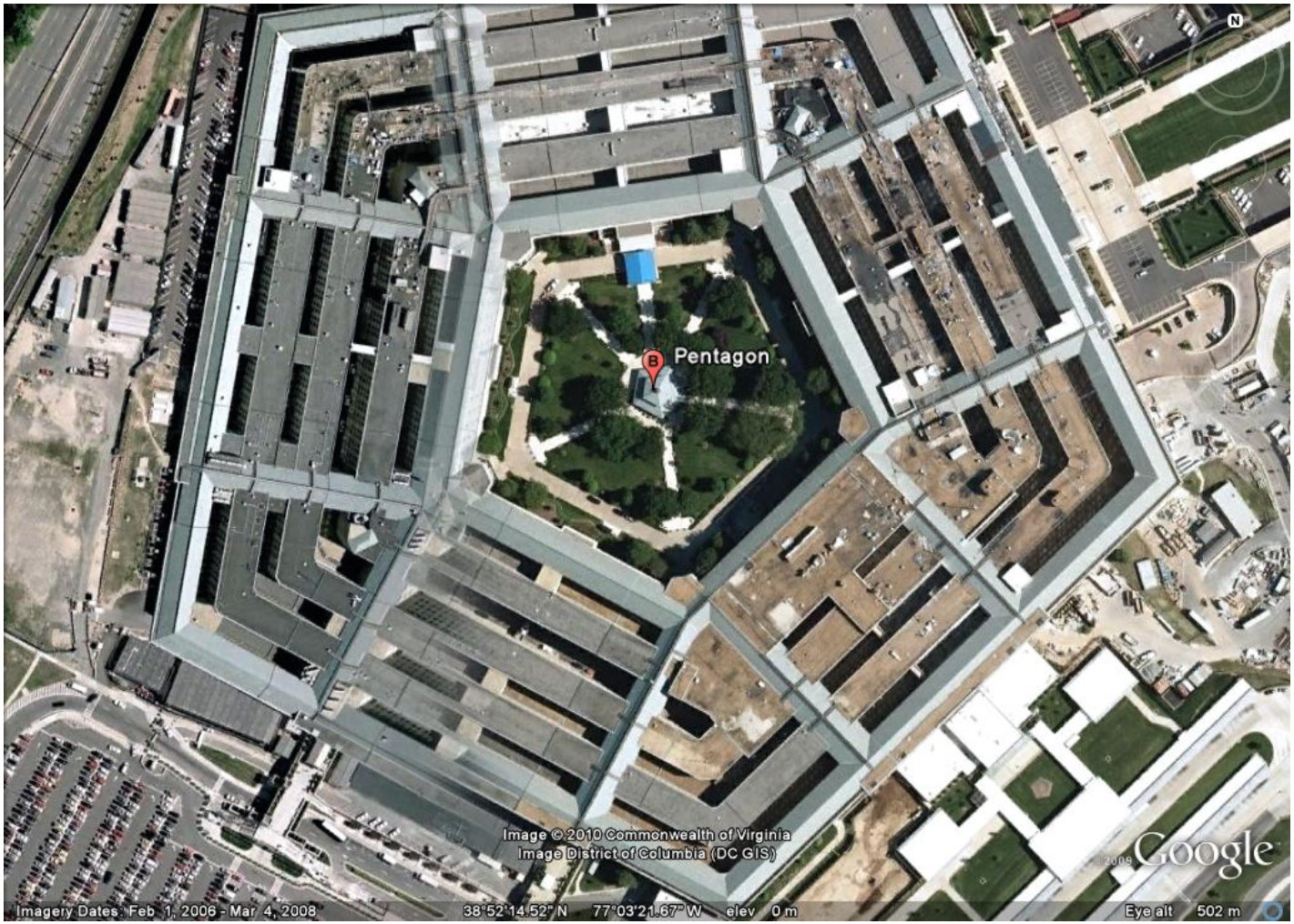
# Pentagon


Pentagon
Image © 2010 Commonwealth of Virginia
Image District of Columbia (DC GIS)
Google
Imagery Dates: Feb 1, 2006 - Mar 4, 2008
38°52'14.52" N 77°03'21.67" W elev 0 m
Eye alt 502 m



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

# Reference Book

Consider a Spherical Cow

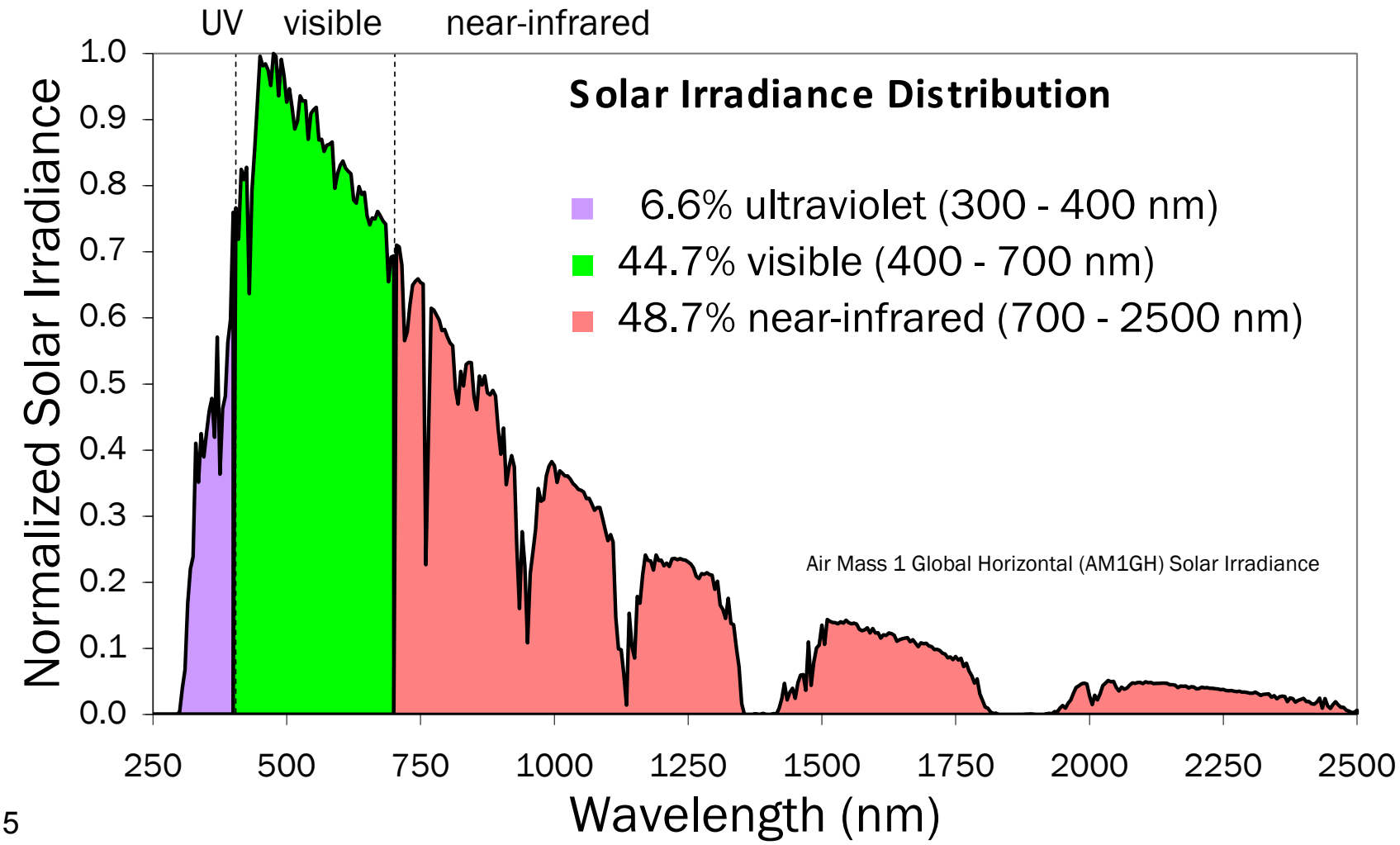
(A Course in Environmental Problem Solving)

By John Harte, UC Berkeley

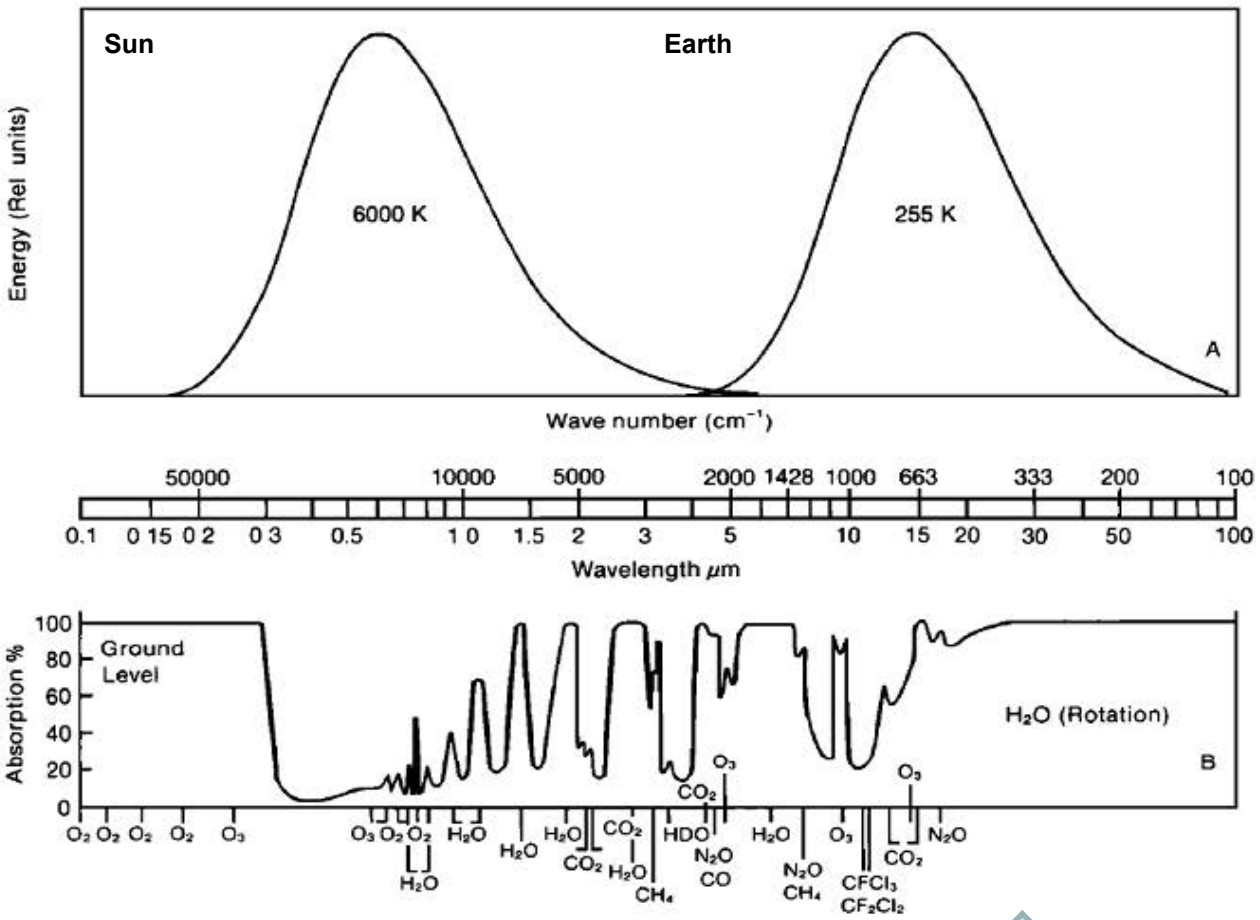
University Science Books, Mill Valley, CA 1988

Urban Heat Islands Ch3.B.9

# Sunlight — more than meets the eye

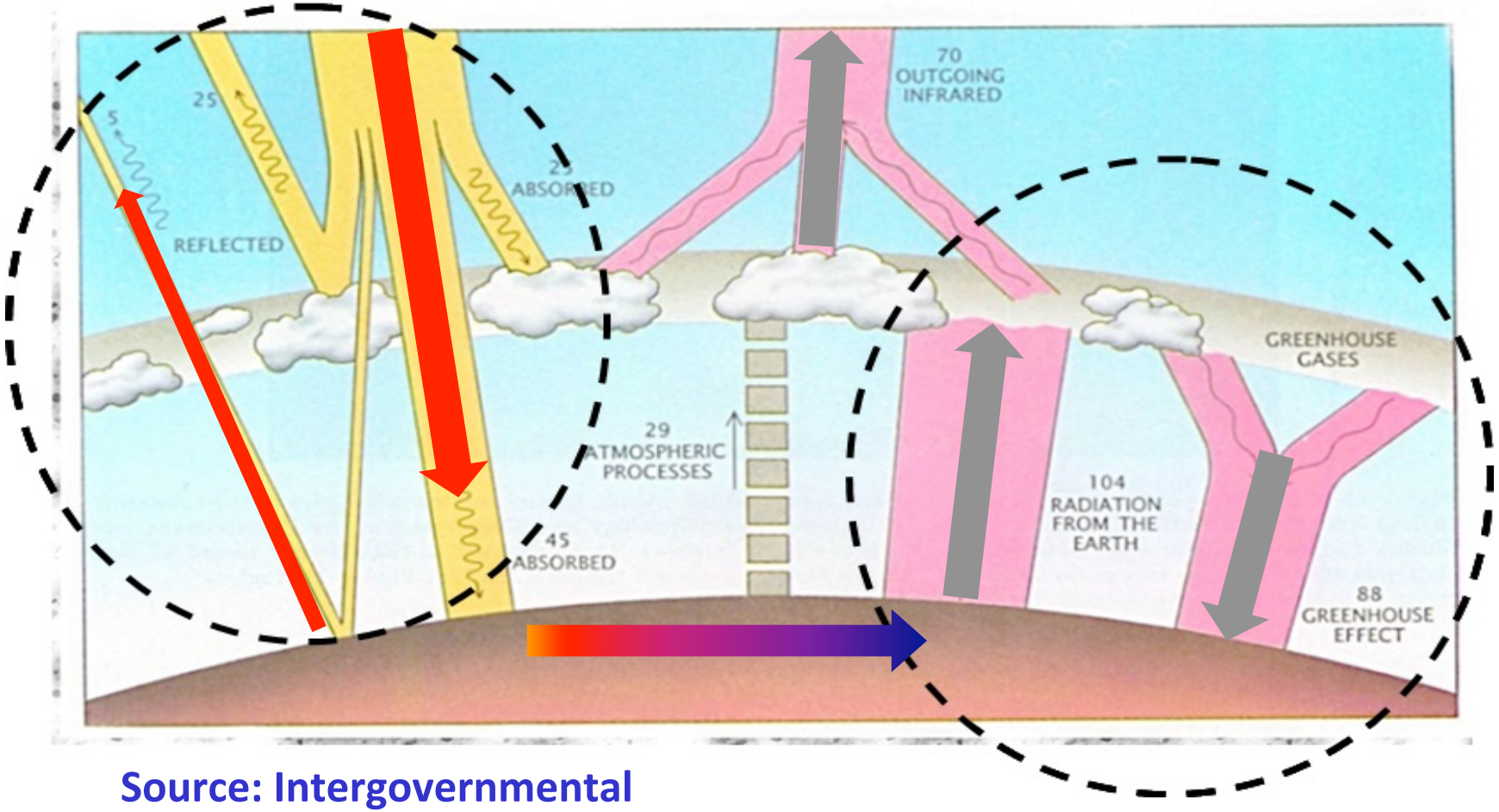


# Atmospheric greenhouse effect (i/ii)




Absorption by the atmosphere

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




Source: Intergovernmental Panel on Climate Change (IPCC)



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Cool, reflective surfaces “offset” the heating effect of CO2 emitted into the atmosphere

**GLOBAL COOLING**: 100 $m^2$ (1000 $ft^2$) of white roof replacing grey offsets the **emission** of 10 t of $CO_2$

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# How much $CO_2$ equivalent is offset if we whiten all eligible urban flat roofs world-wide? (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 ≈ 1.2 Gt/year.

# How much $CO_2$ 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 ≈ 4 t $CO_2$/ 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* CO2 back at the power plant.

# 3 papers and 1 memo estimate tonnes of $CO_2$ offset by 100 $m^2$ (1000 $ft^2$) of white roof. May 2010

| | Study (available at CoolWhitePlanet.org) | Method | Cloud cover esti-mation | $CO_2$ offset (atmos-pheric) per 100 $m^2$ | $CO_2$ offset (emitted) per 100 $m^2$ | World-wide potential $CO_2$ offset (emitted) from cool roofs | $CO_2$ 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) [$CO_2$ 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 $CO_2$ *emitted* only 0.55 tonnes remain in the *atmosphere* after one year, 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 28th, 2011. They estimate 7 tonnes of CO2 offset per 100 m2 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**.

LAWRENCE BERKELEY NATIONAL LABORATORY PRESENTS:
SCIENCE AT THE THEATER

# 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.**

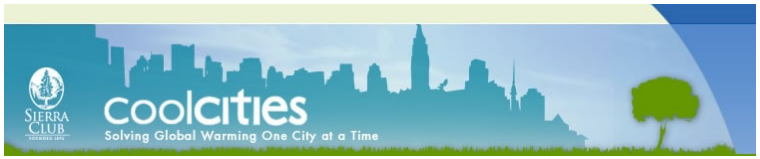
# Recent cool roof progress (2005 – 2011)

- 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 1st, 2010 – Memo from U.S. Energy Secretary Steven Chu calls for all DOE Buildings to have white roofs, if cost-effective
  - June 16th, 2010 – Marine Corp follows suit, Pentagon following slowly
  - June 19th, 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
  - 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



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
- Cool Colors Project
  - CoolColors.LBL.gov
- Heat Island Group
  - HeatIsland.LBL.gov
- Cool Communities Project
  - CoolCommunities.LBL.gov
- Roof Savings Calculator
  - RoofCalc.com
- Global Cool Cities Alliance
  - GlobalCoolCities.org
- Cool Roof Rating Council
  - CoolRoofs.org
- Cool California
  - CoolCalifornia.org
- EPA Heat Islands
  - epa.gov/heatisland
- Energy Star Cool Roofs
  - EnergyStar.gov