Urban Heat Island Countermeasures to Cool the Kansas City Region

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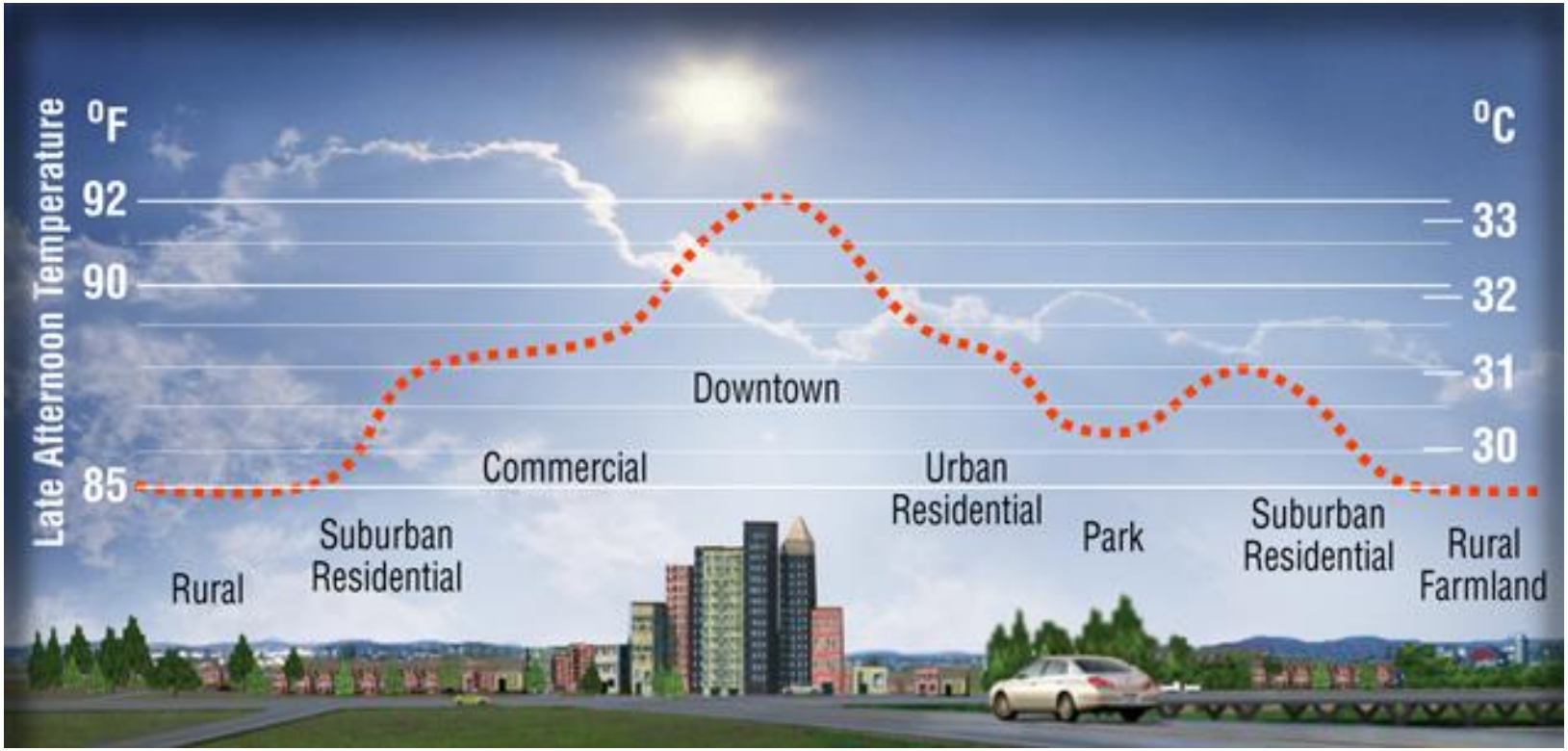
1. The Urban Heat Island

Hot town—summer in the city

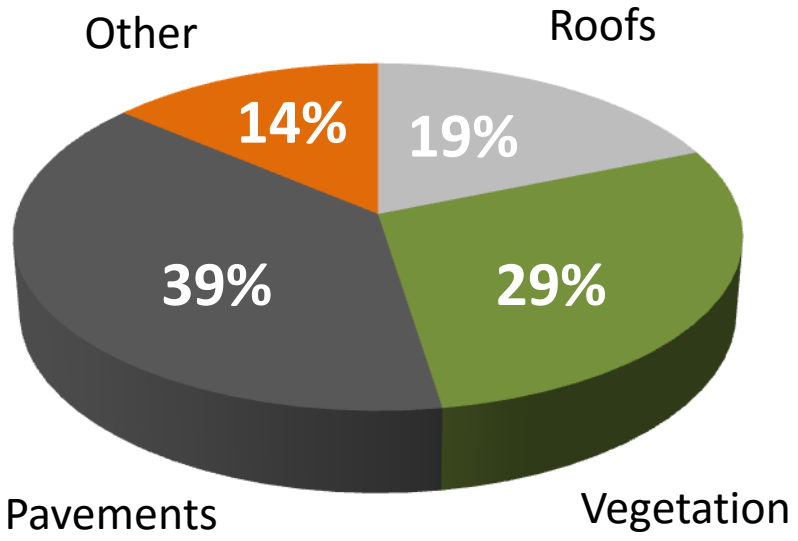


a summer urban heat island

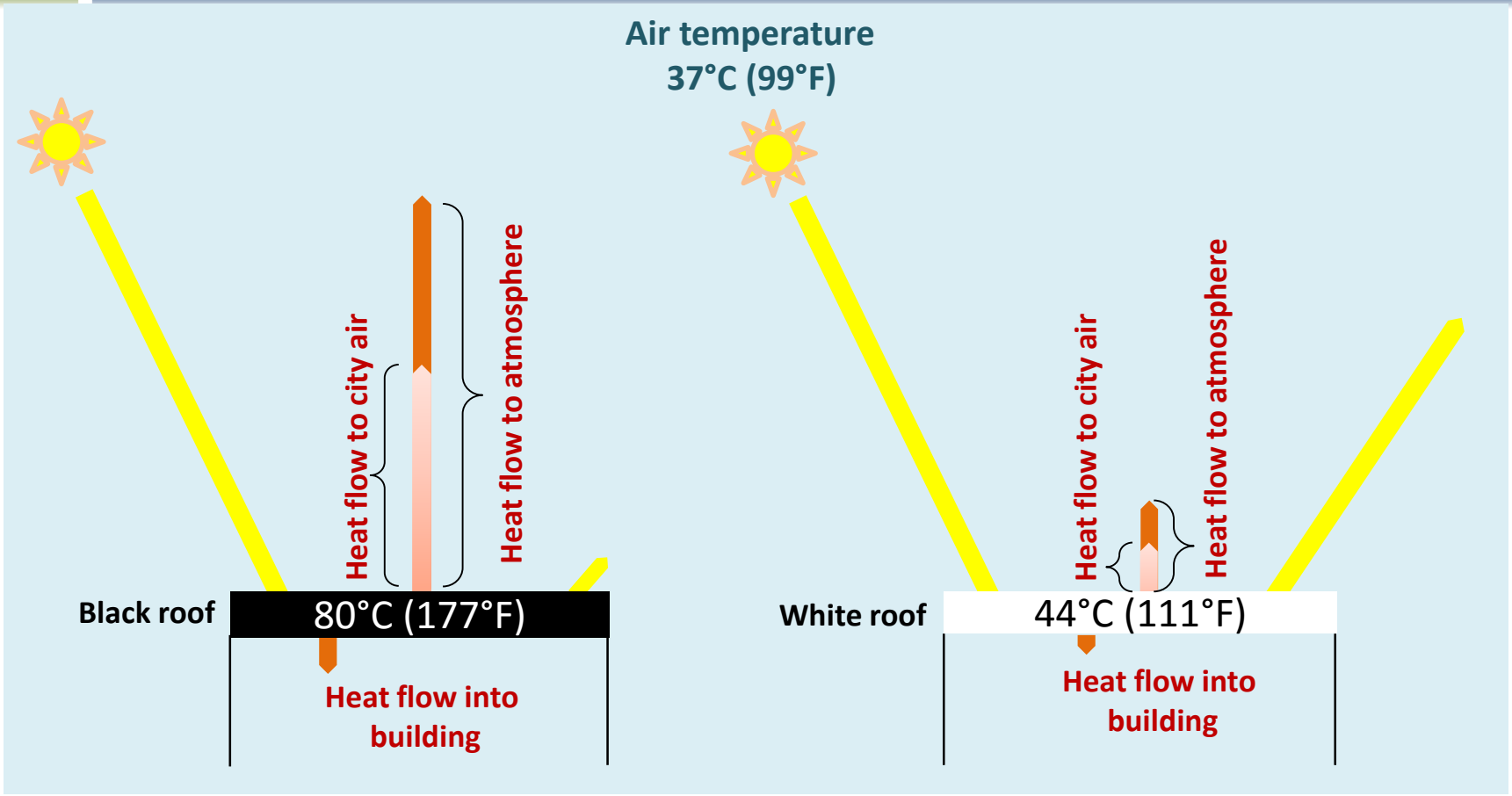
What makes cities warm?

Sacramento, California (≈ 1 km^2)

One reason:
many dark surfaces.



Roofs with high solar reflectance cool our buildings, cities, and planet

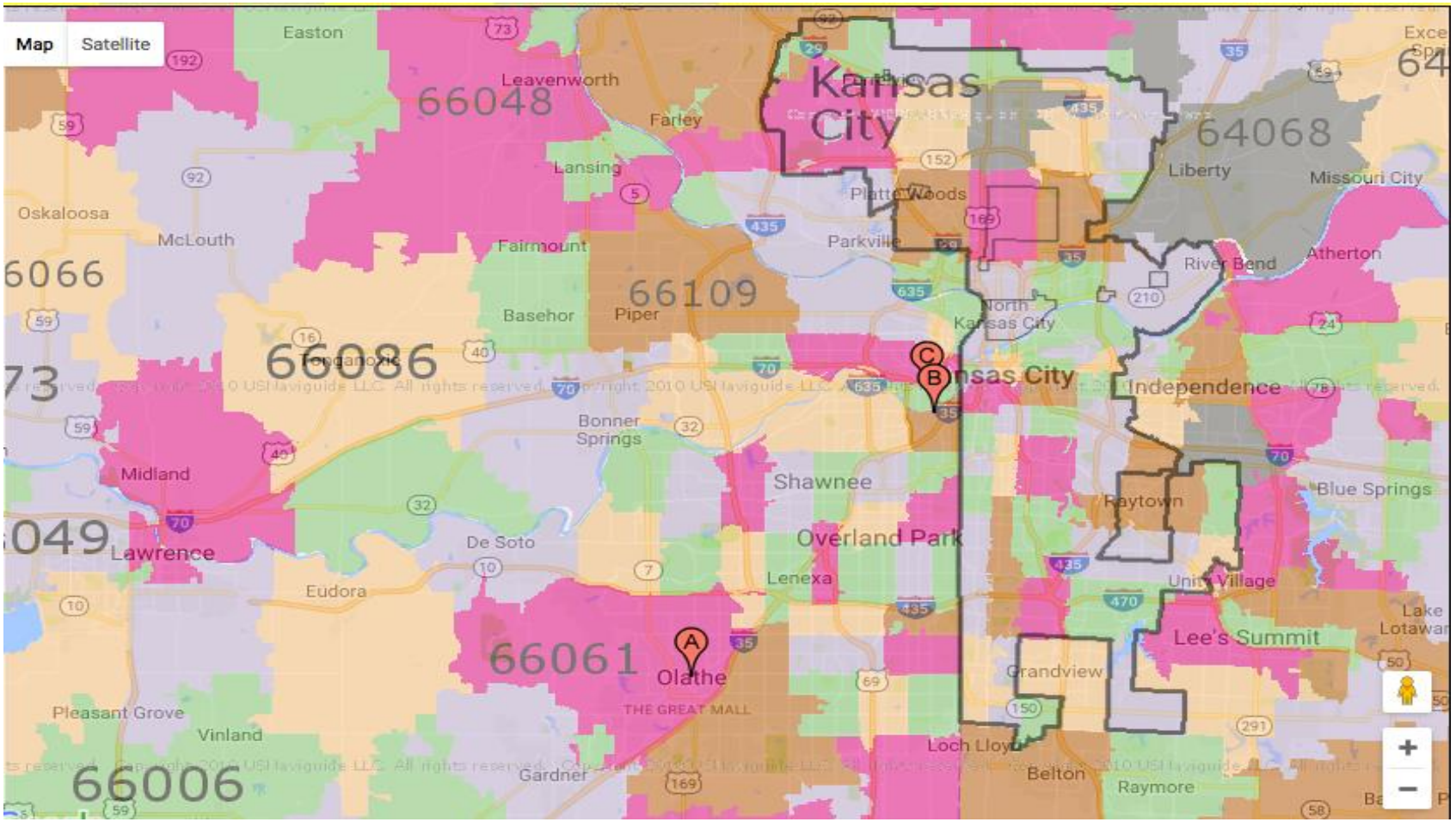


2. Air Conditioning Use vs. Outside Air Temperature

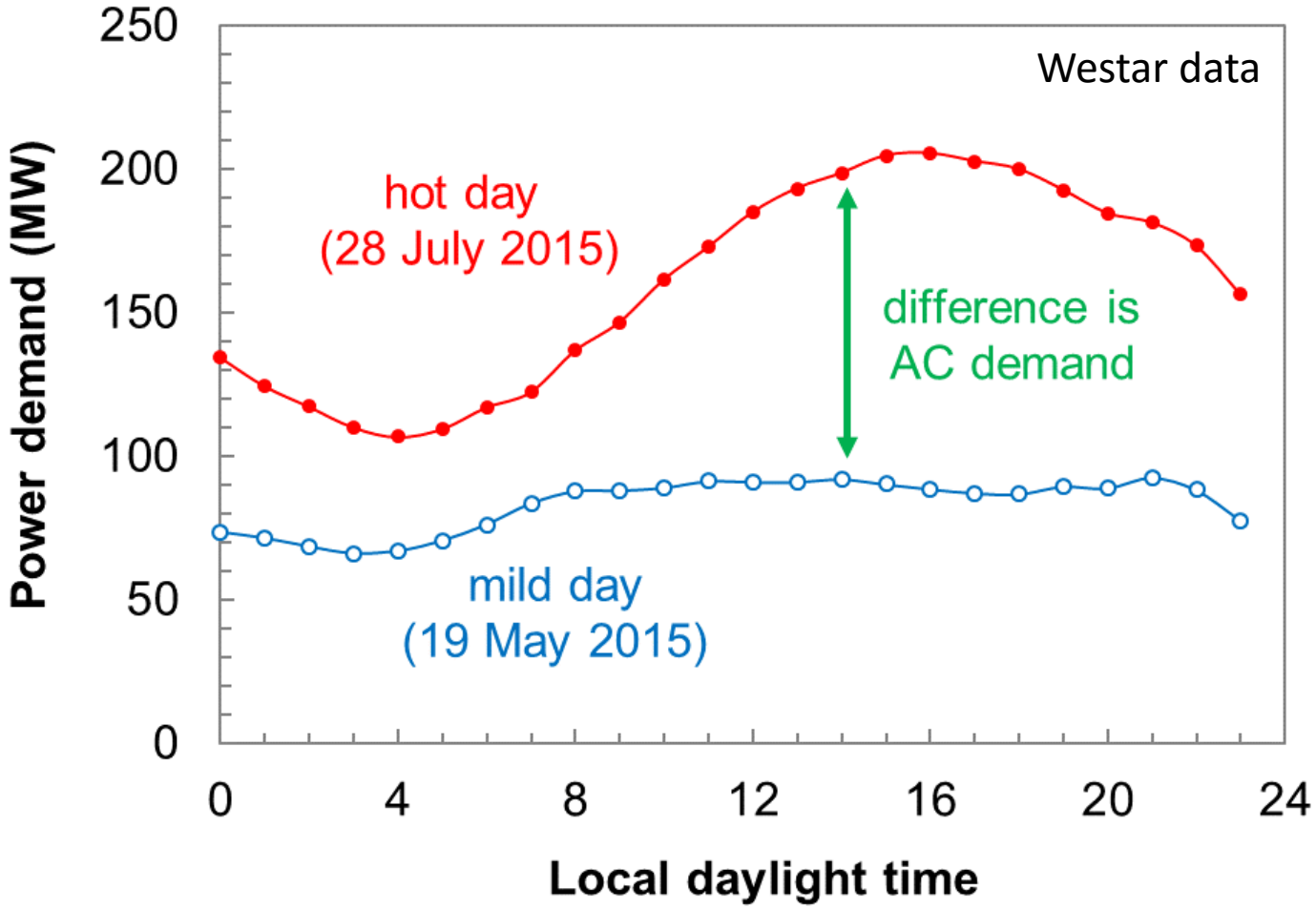
(Melvin Pomerantz, M_Pomerantz@LBL.gov)

MARC and LBNL are working with local utilities to collect electricity use data

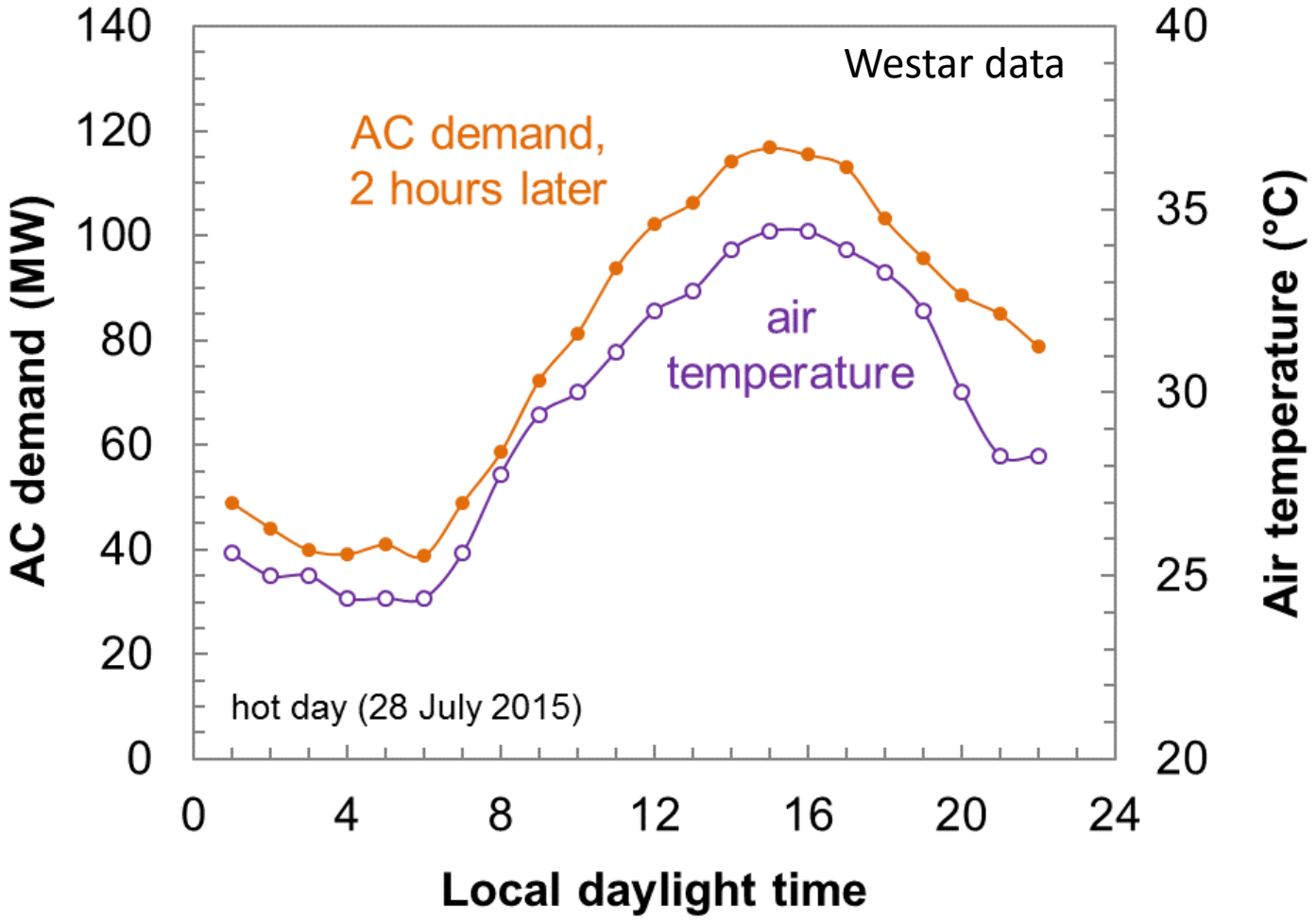
Example: Westar Energy shared hourly electrical demand for a few ZIP codes outside K.C.



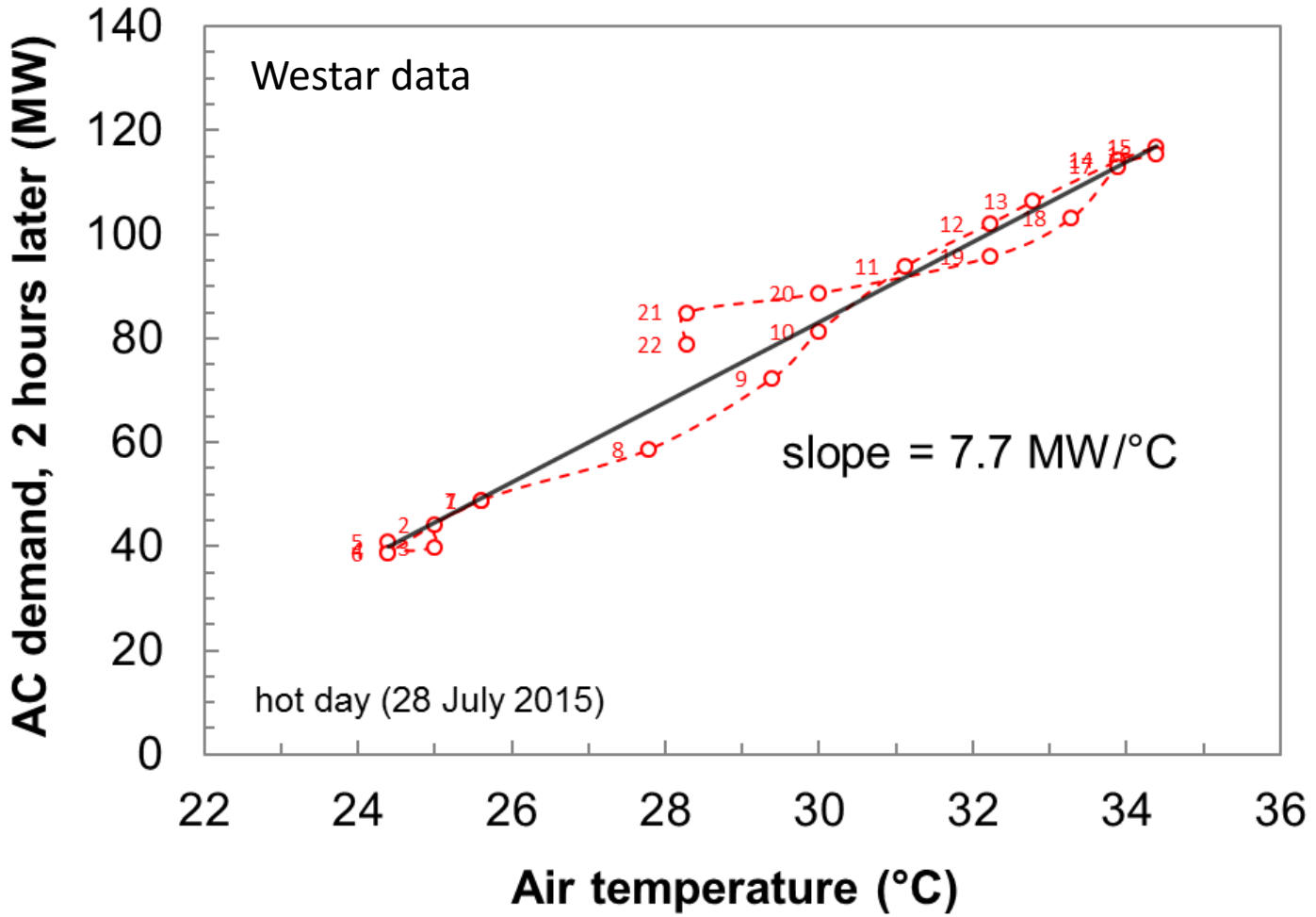
We compared power demands on hot/mild days equally spaced about summer solstice



AC power demand tracks outside air temperature with 2 hour lag



AC demand (2 hours later) scales almost linearly with outside air temperature



Energy and energy cost savings from air temperature reduction can be small

- Raising by 0.20 the albedo of all pavement (1/3 of urban area) in a California city would
  - lower outside air temperature by < 1 °C
  - save considerably less than 2 kWh of AC energy each year per m^2 of pavement modified
  - save < \$2/m^2 of pavement modified over 10-year service life, assuming cooling-season time-of-use electricity price of \$0.70/kWh
- **To be economical, savings must exceed cost**
  - pavements doubtful, roofs likely feasible
  - see Pomerantz et al. 2015, *Urban Climate*, http://dx.doi.org/10.1016/j.uclim.2015.05.007

3. Heat Island Countermeasures

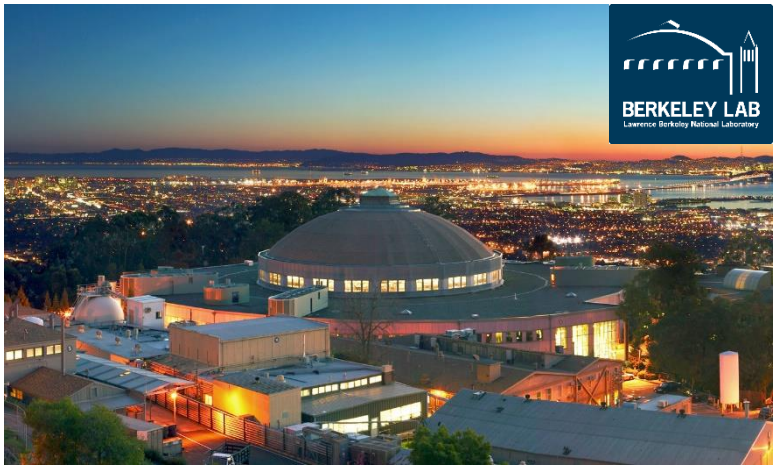
(Dev Millstein, DMillstein@LBL.gov)

MARC and LBNL will assess the K.C. region UHI and plan countermeasures

- The Mid-America Regional Council (MARC) is the regional and metropolitan planning organization serving the 119 local governments in the bi-state, 4,423-square mile Kansas City region.
- The Heat Island Group at Lawrence Berkeley National Laboratory (LBNL) seeks to cool buildings, cities, and the planet.

MARC

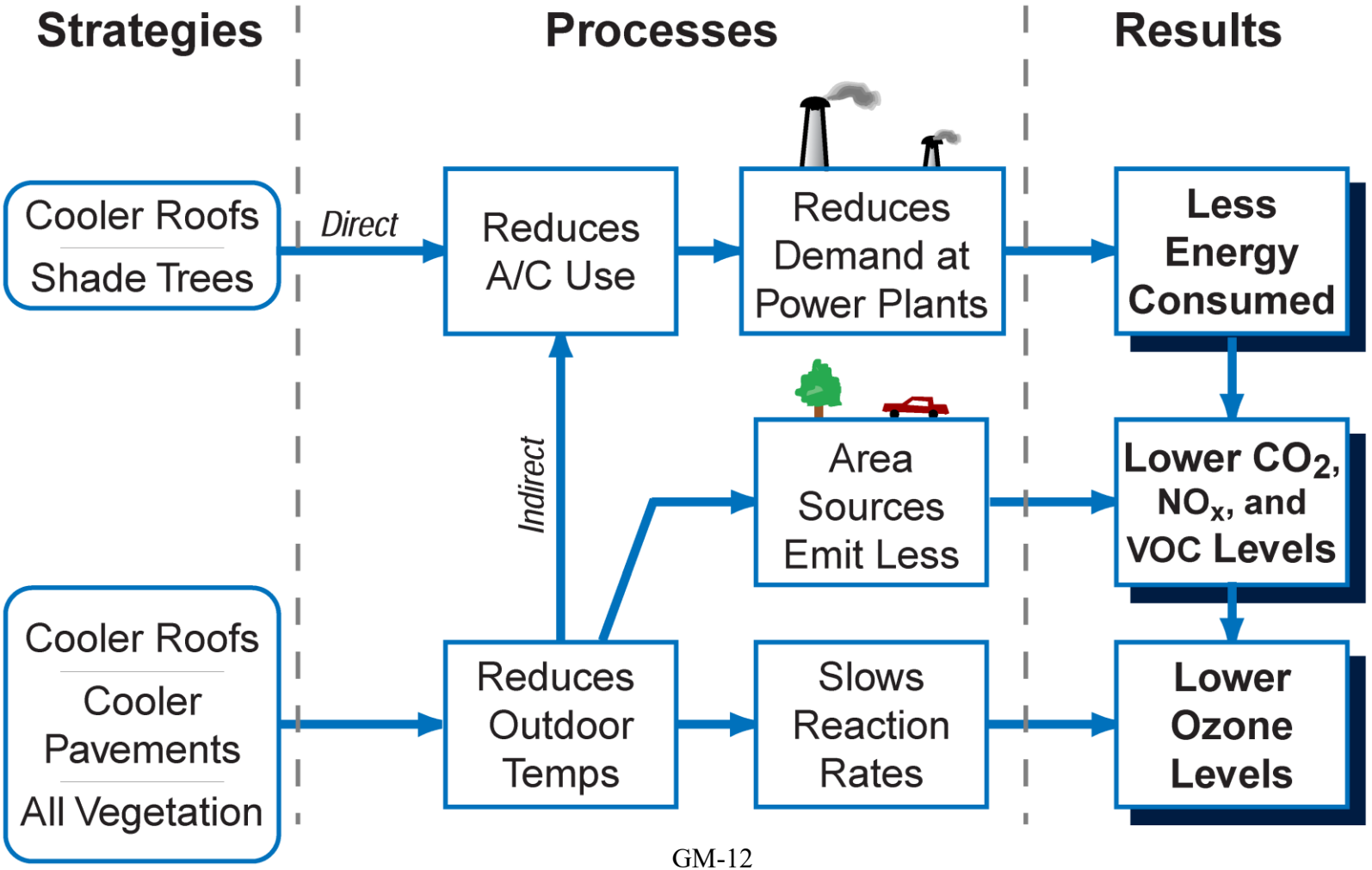
MID-AMERICA REGIONAL COUNCIL



Many strategies have been proposed to mitigate urban heat islands

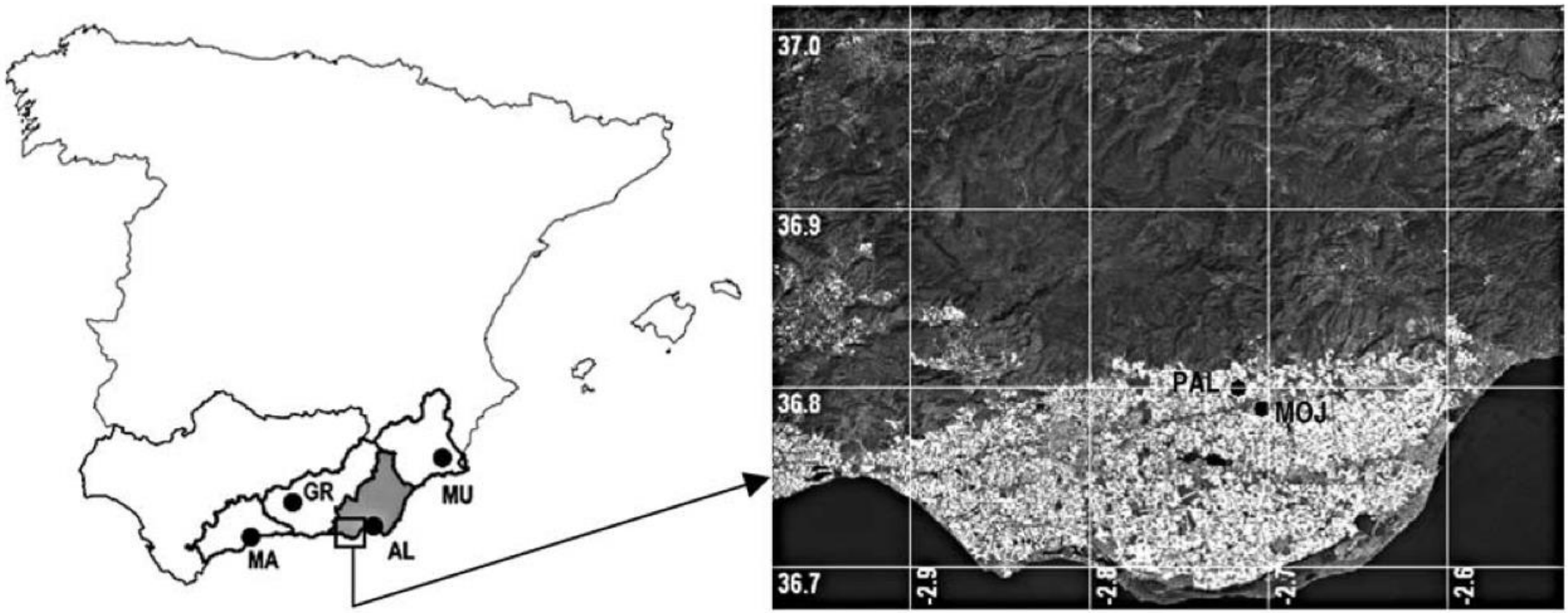
1. Increase the reflectance of roofs
2. Increase the reflectance of pavements
3. Increase the reflectance of walls
4. Install garden (“green”) roofs
5. Add trees or other plants at ground level
6. Reduce waste heat from human sources (“anthropogenic” heat)
7. Irrigate the city

Countermeasures can save energy, improve comfort, and boost air quality



- Observations and simulations indicate that reflective surfaces can cool cities.

Reflective roofs have been observed to cool outside air in Almeria, Spain

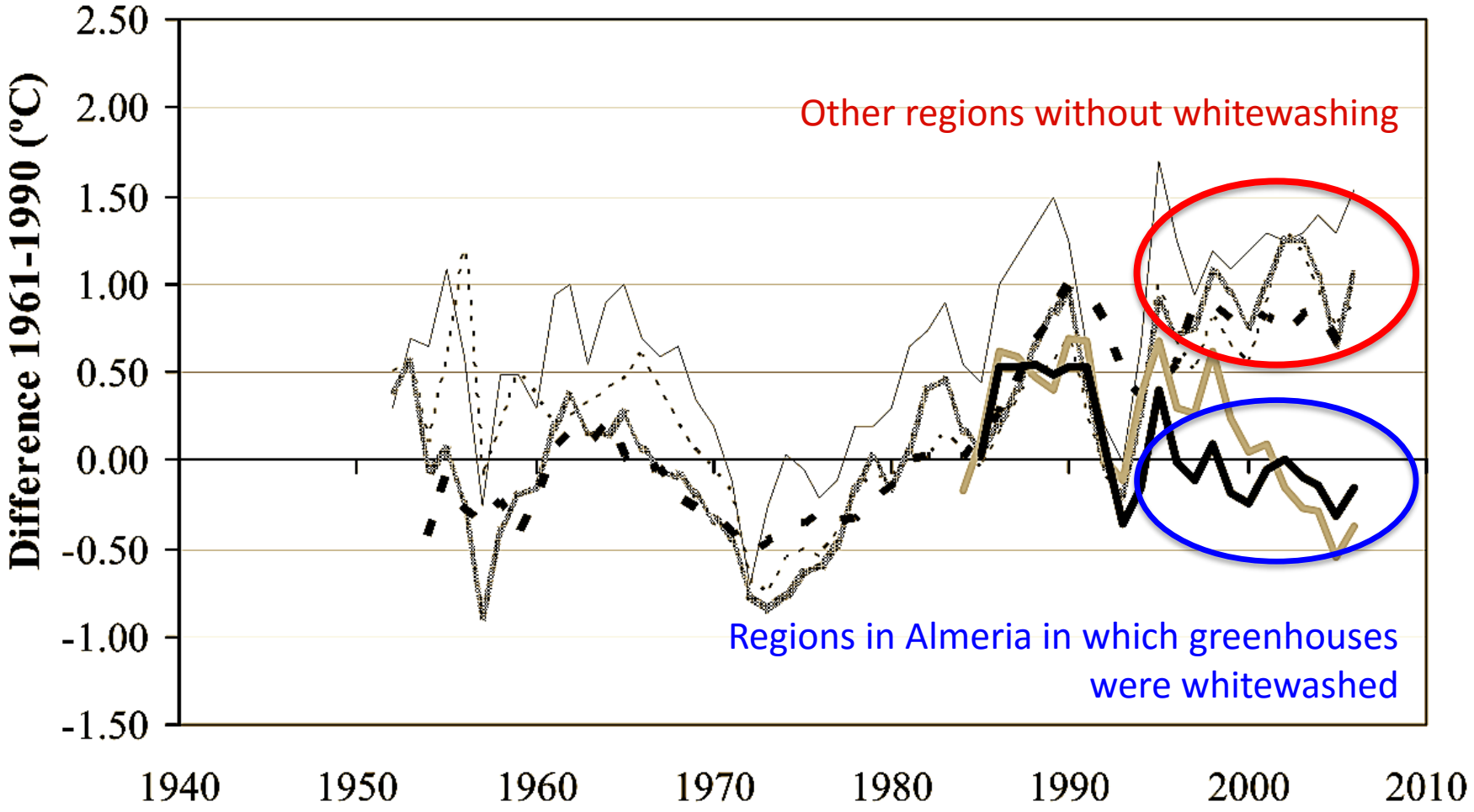


Farmers in Almeria started white-washing greenhouse roofs in summer to lower the temperature inside. These roofs can be seen by eye from the International Space Station!

Campra et al. 2008. *J. Geophys. Res. Atmos.*, http://dx.doi.org/10.1029/2008JD009912

Whitewashed roofs in Almeria, Spain

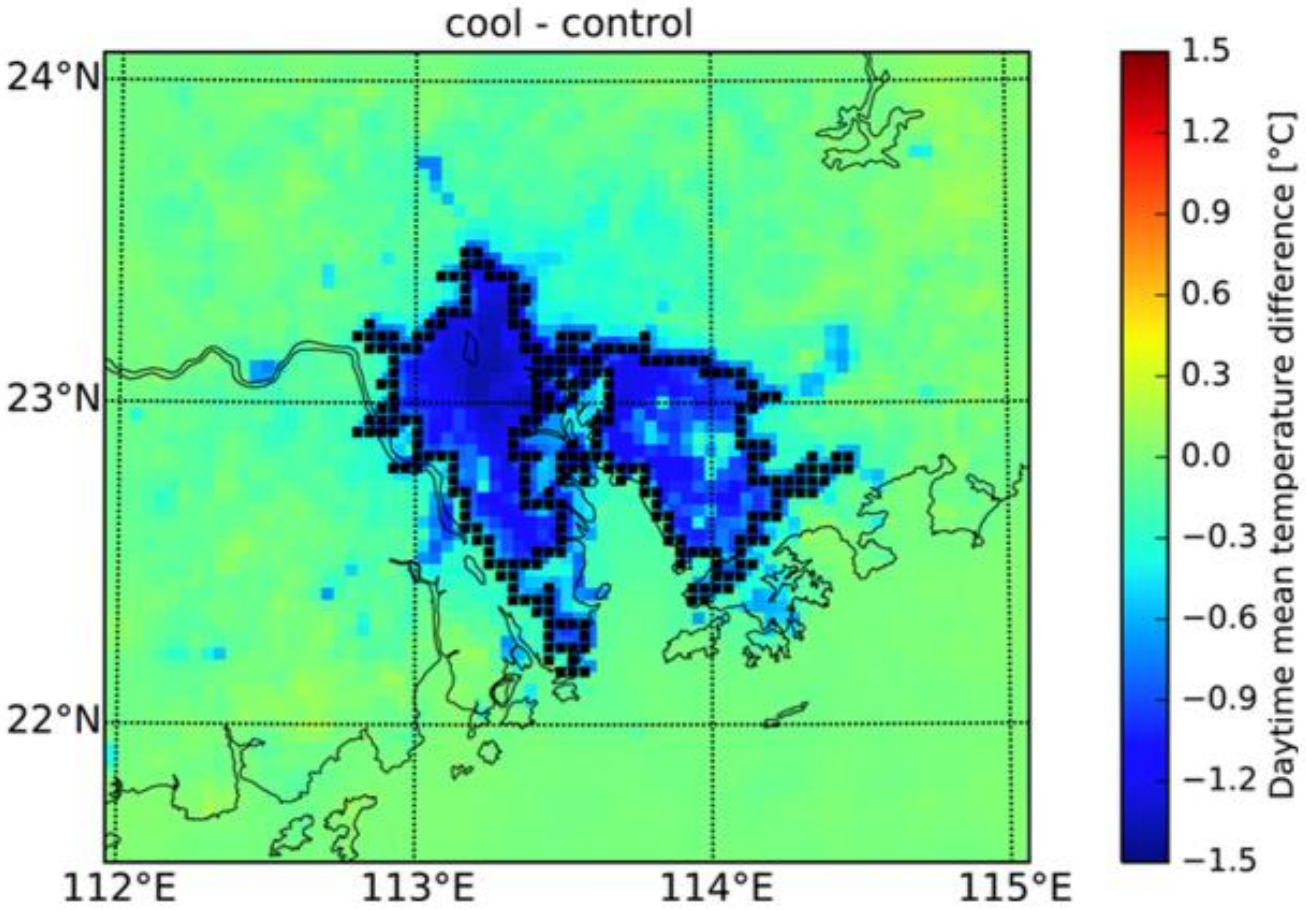
Measured outdoor air temperatures in Almeria fell as whitewashing peaked in the late 1990s



Campra et al. 2008. *J. Geophys. Res. Atmos.*, http://dx.doi.org/10.1029/2008JD009912

Modeling indicates widespread cool roofs could lower mid-day summer air temperatures in megacities by 1 °C

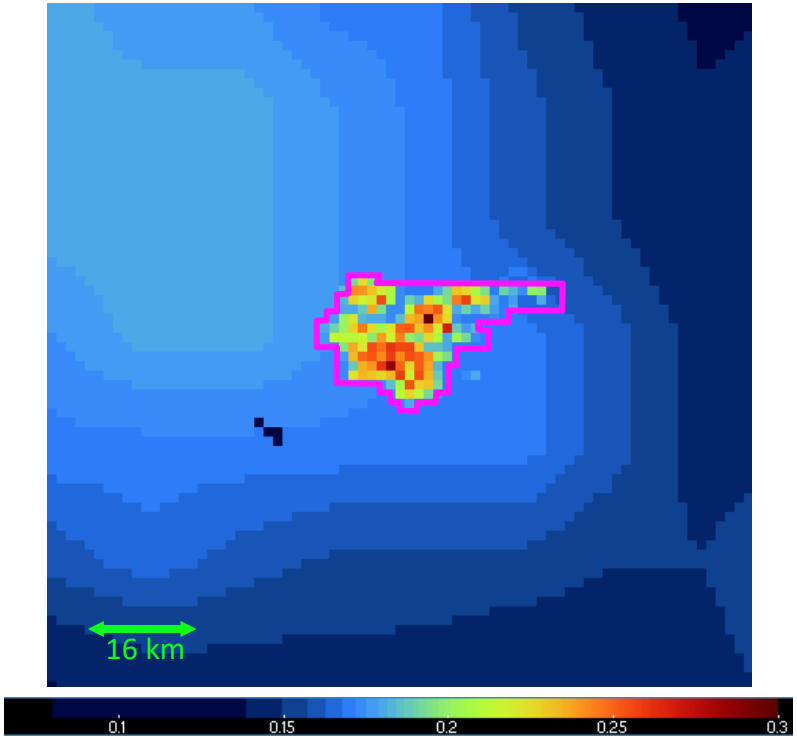
Daytime mean temperature change in Guangzhou, China (°C)



Cao et al. 2015. *Environmental Science and Technology*, http://dx.doi.org/10.1021/acs.est.5b04886

While even small cities can benefit, air must flow over a few km of cool surfaces to detect temperature change

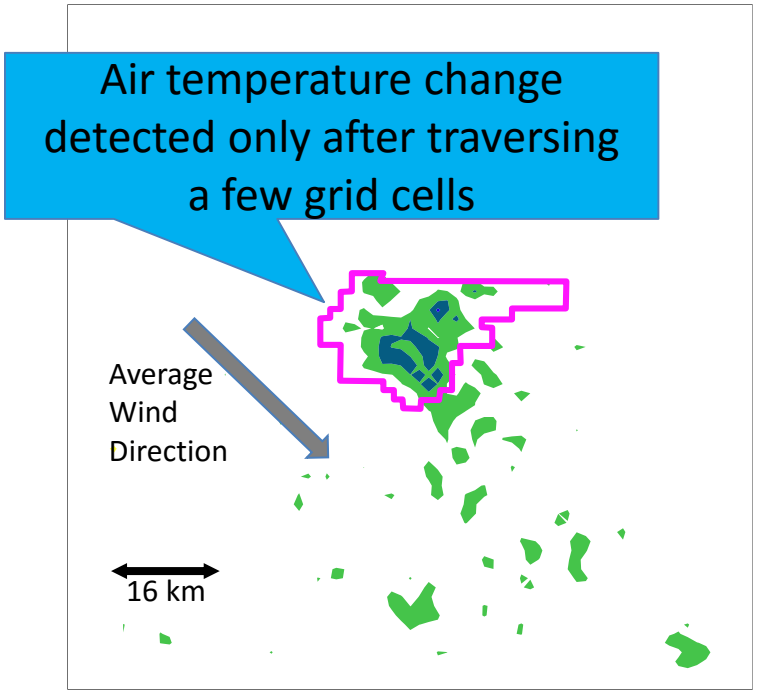
Bakersfield, CA was simulated before and after increasing roof & pavement albedos.



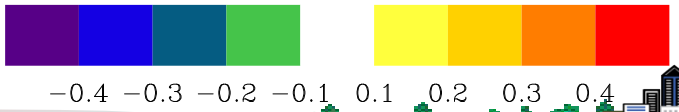
“Cool” case albedos

Albedos 0.60, 0.35, and 0.30 for flat roofs, sloped roofs, and pavements; maximum grid cell albedo increase ~0.15.

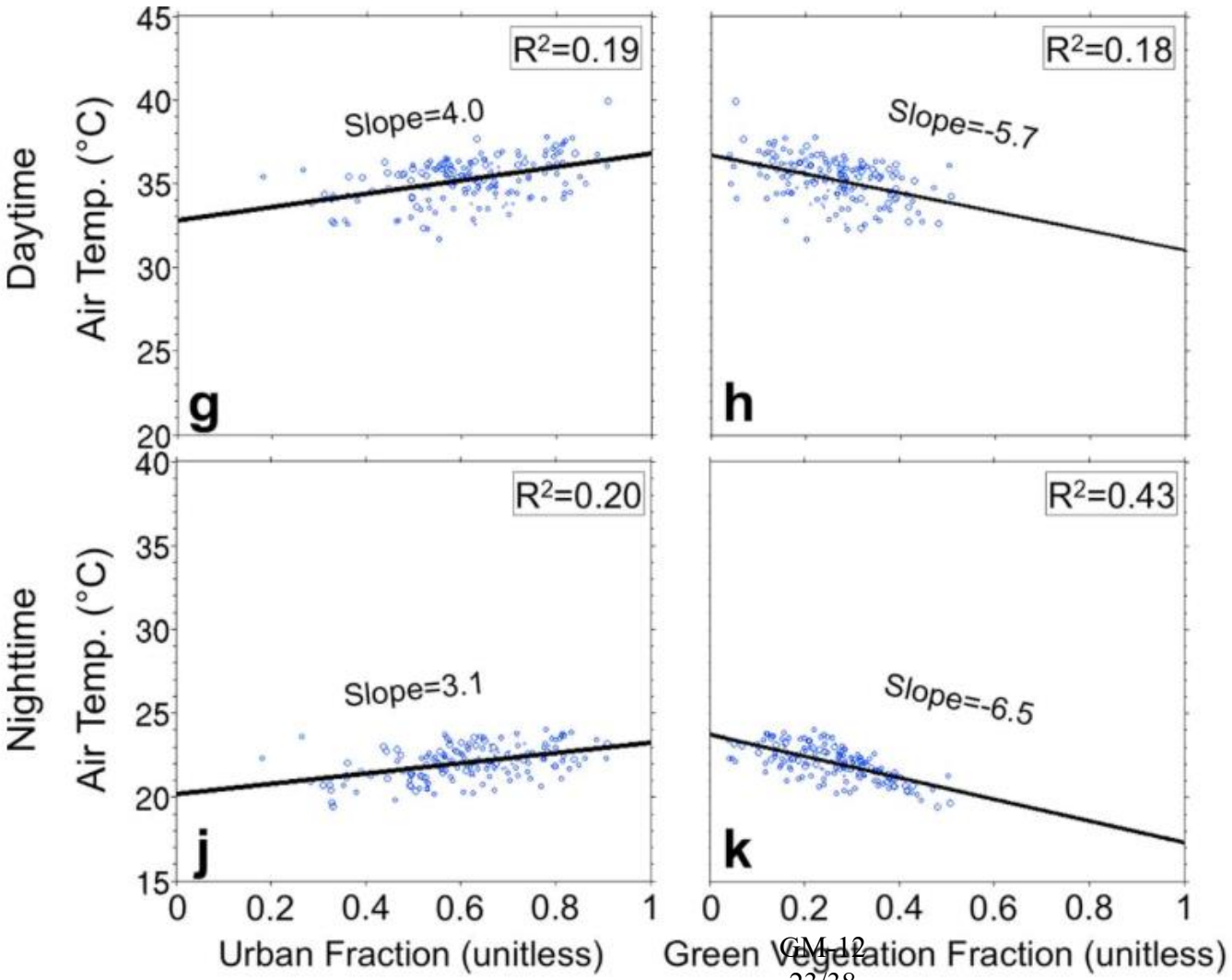
Change in 2 m air temperature on summer afternoon



Each grid cell is 1.3 km × 1.3 km



Modeling also supports increasing urban vegetation as a heat island countermeasure



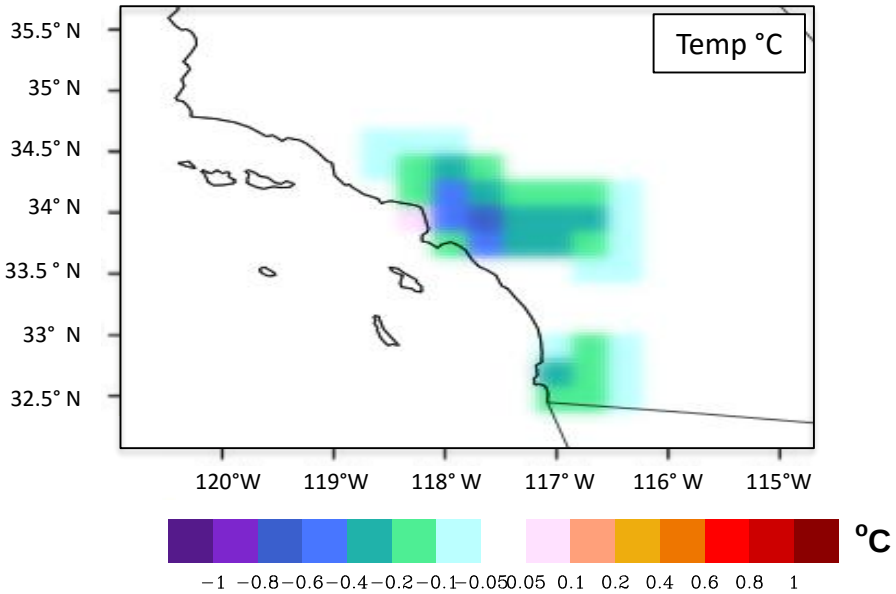
Los Angeles simulations correlated higher air temperature to increased urbanization and reduced vegetation.

Vahmani and Ban-Weiss. 2016. J. Geophys. Res. Atmos. http://dx.doi.org/doi:10.1002/2015JD023718

- But wait, there's more!

Cooling the air can slow formation of smog

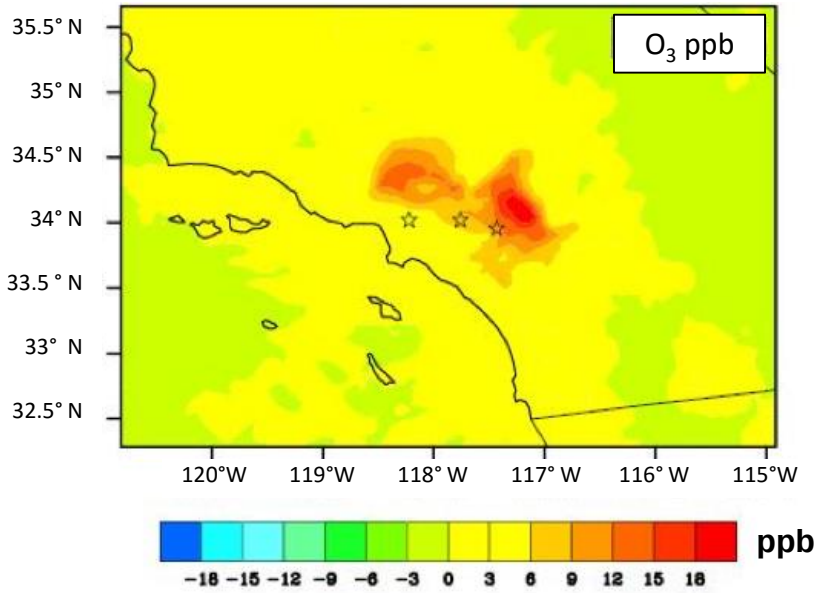
Modeled change in average summer afternoon air temperature from increasing the albedo of roofs (+0.25) and pavements (+0.15) in the Los Angeles basin



Grid cell albedo increase was 0.11 in downtown Los Angeles

Millstein & Menon 2011. *Env. Res. Let.*, http://dx.doi.org/doi:10.1088/1748-9326/6/3/034001

Modeled change in ozone concentration from increasing outdoor air temperature in southern California by about 2 °C



Millstein & Harley. 2009. *Atmos. Chem. Phys.* http://dx.doi.org/10.5194/acp-9-3745-2009

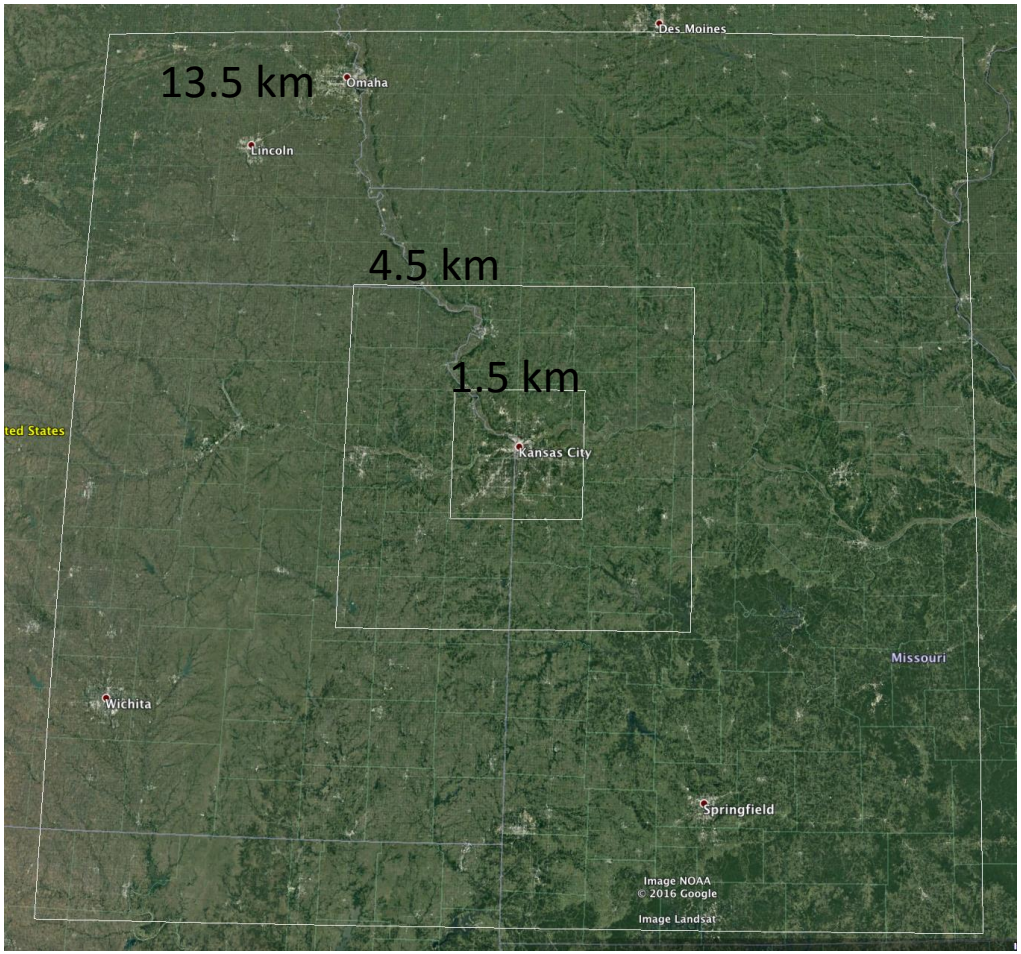
4. Preliminary Meteorological Modeling of the Kansas City Region

(Dev Millstein, DMillstein@LBL.gov)

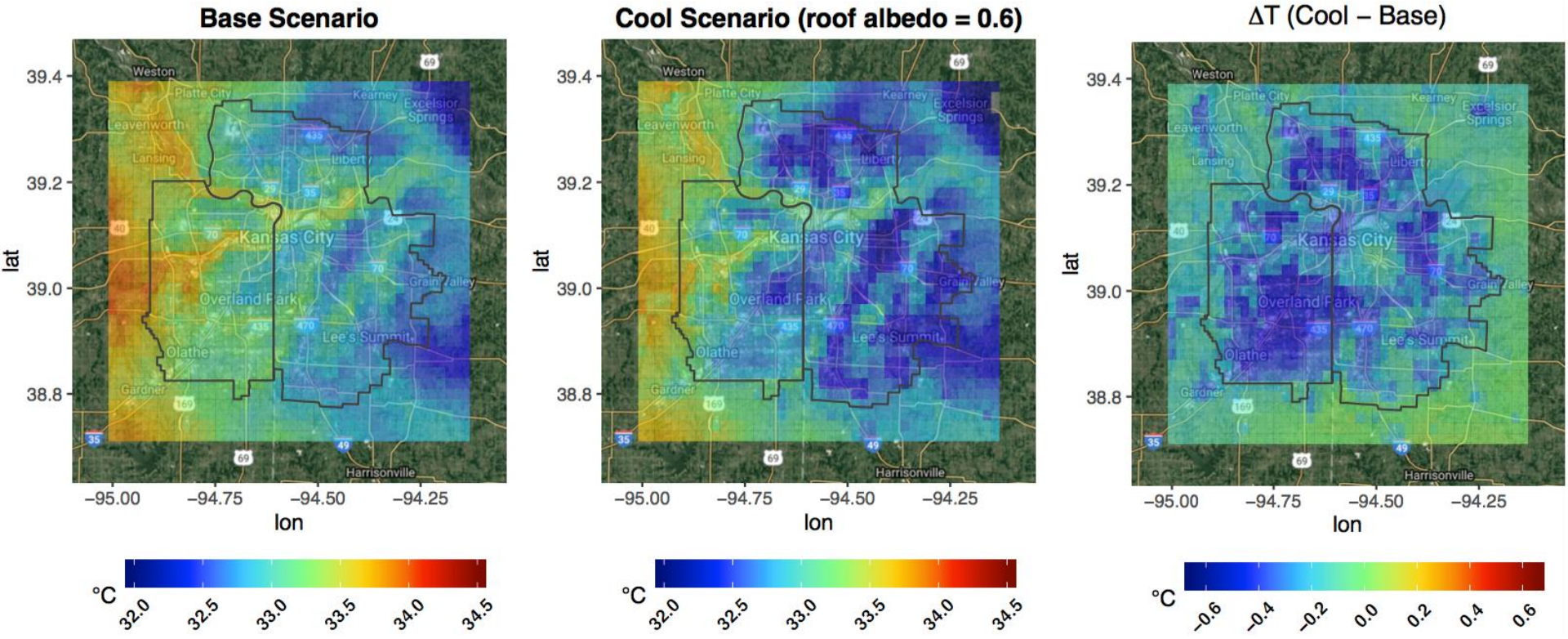
First simulations evaluated a cool roof strategy

- Compared cool-roof and base-case scenarios (roof albedo raised to 0.6 from 0.2)
- Details:
  - Calculated difference (cool - base) in near-surface air temperature at 2 pm LST
  - Jul + Aug (7 days per month), 2011 – 2015
    - Total of 70 days per scenario
  - Weather Research & Forecasting (WRF) v. 3.8
  - High resolution (1.5 km) for the inner domain

Modeling domain resolves the Kansas City area with 1.5 by 1.5 km grid cells



Cool roofs reduced average urban temperature by up to 0.4 °C



Results average the 70 days of simulations and assume all roofs are made cool.

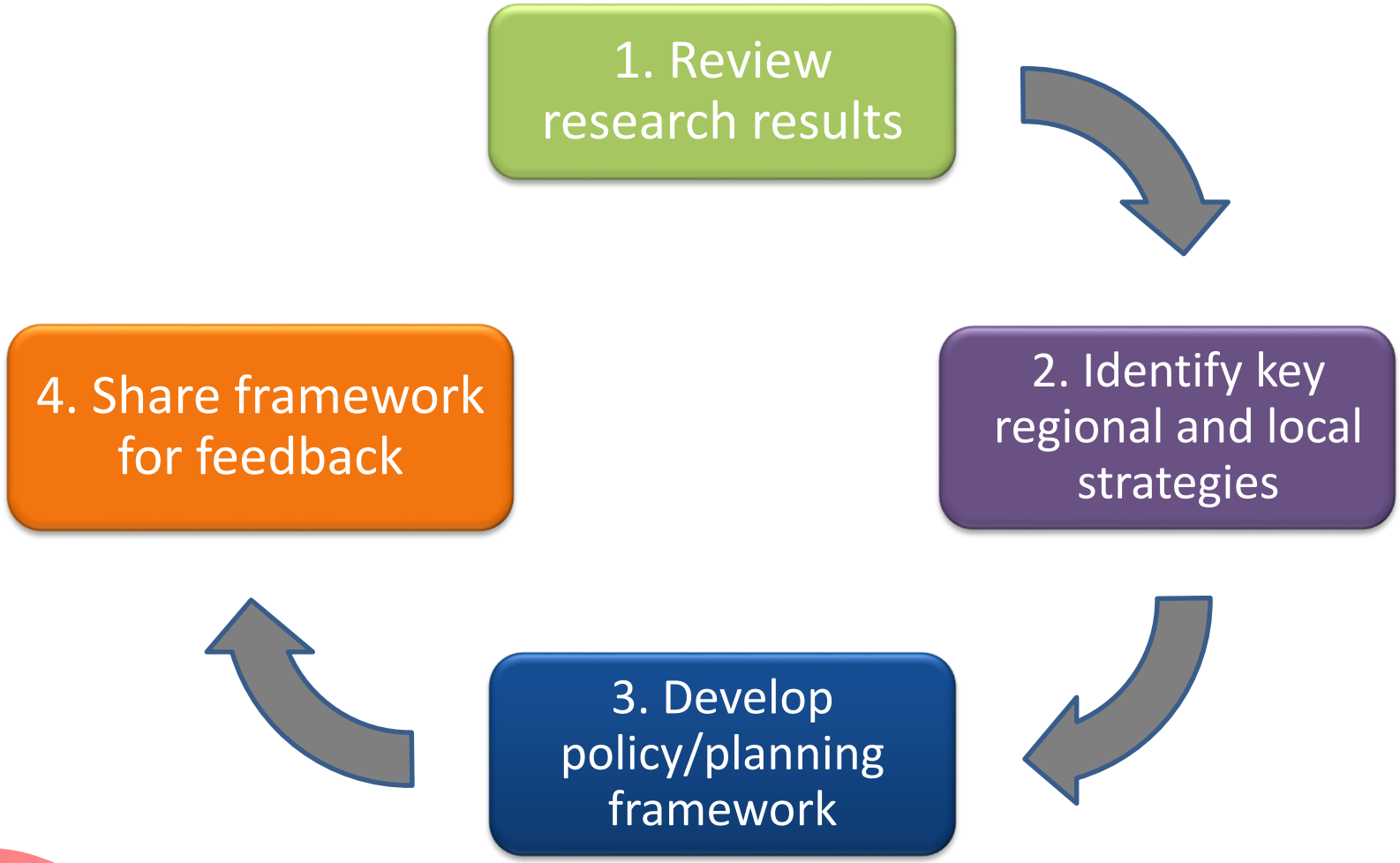
Other scenarios will be explored

- Planting shade trees or other vegetation
- Greater benefits during heat waves?

5. Policy and Planning

(Haley Gilbert, HEGilbert@LBL.gov)

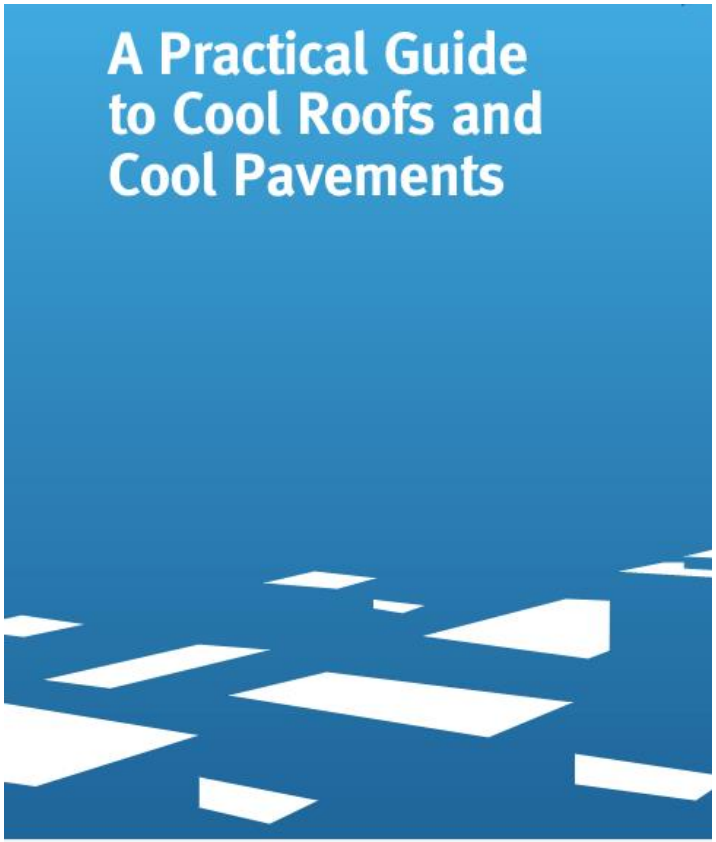
MARC and LBNL will create policy/planning framework to support local UHI countermeasures



MARC and LBNL will facilitate local implementation of UHI countermeasures

- Host webinars/workshops
- Organize a charrette (summer 2017)
- Present at conferences and publish to share project research and results

MARC and LBNL will develop guidance to support similar UHI research and policy efforts nationwide



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green infrastructure toolkit

6. Good Stuff Online

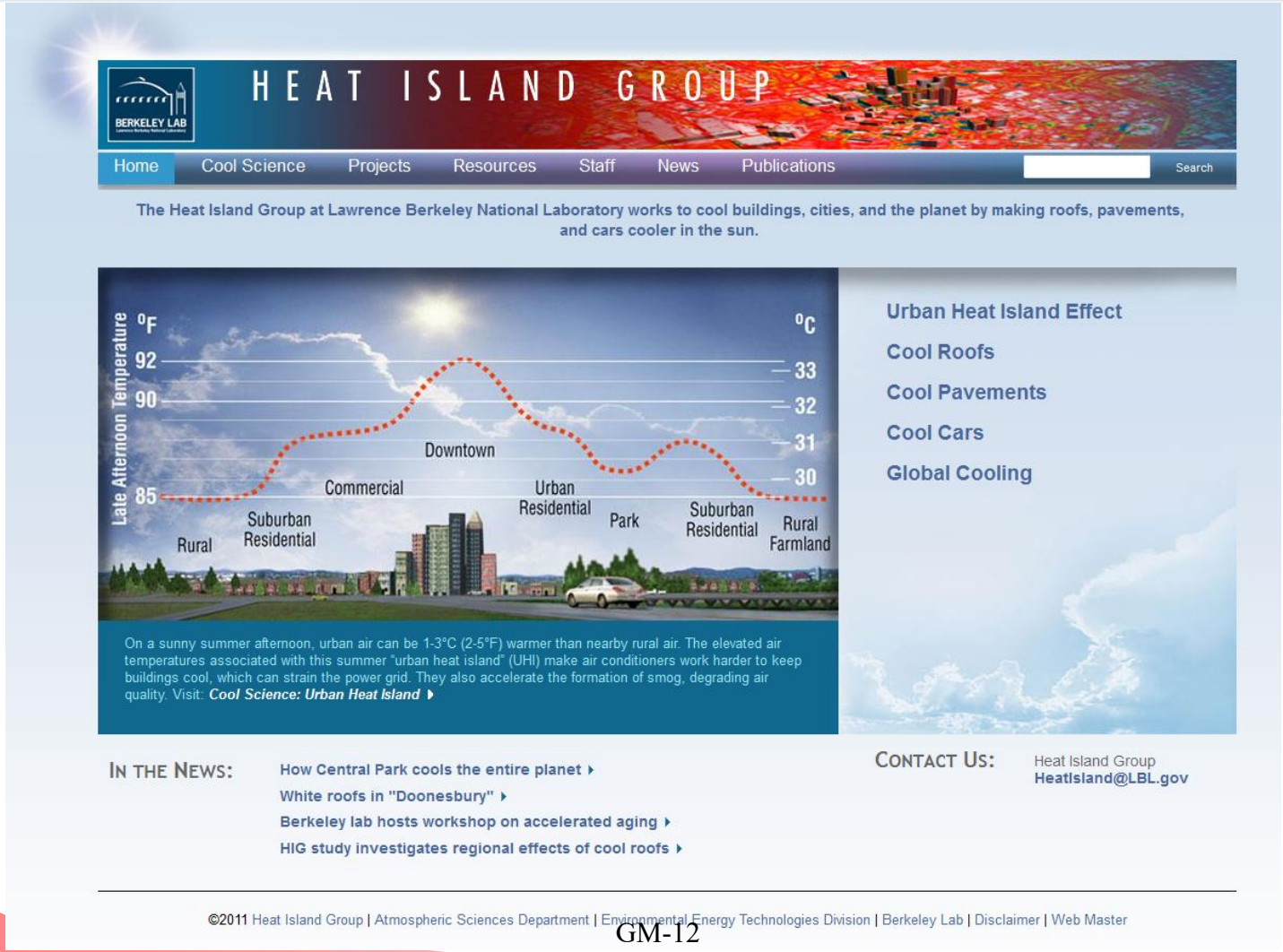
Global Cool Cities Alliance offers UHI mitigation resources for officials, experts, and the public

- Science, costs, and benefits of cool surfaces
- Global best practices for program and policy implementation
- Sample materials and relevant organizations.
- A comprehensive "knowledge base"
- Networking Forum

CoolRoofToolkit.org

Heat Island Group website

HeatIsland.LBL.gov



Thank you!