Cooling the World by Installing Urban Reflective Surfaces

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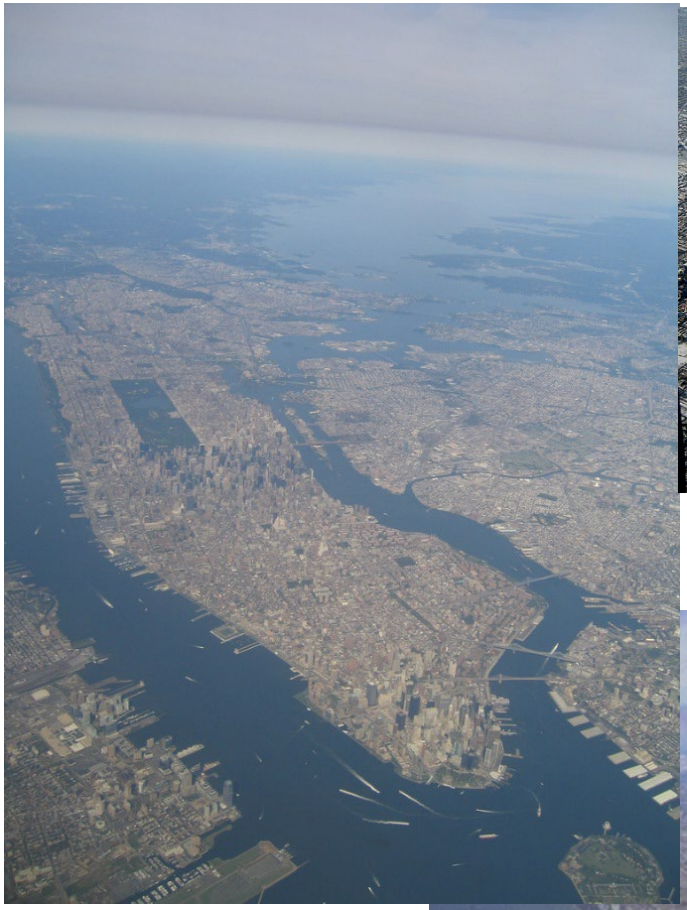
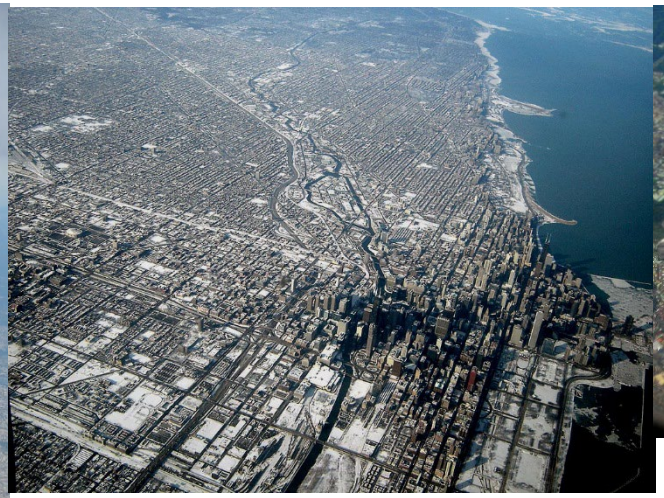
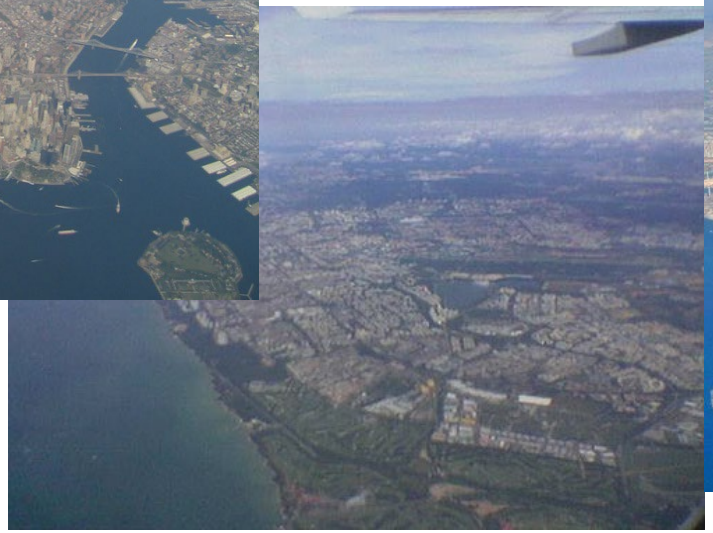
Urban areas: Dark roofs and pavements







Cool surfaces reduce energy use, cool outdoors, counter global warming

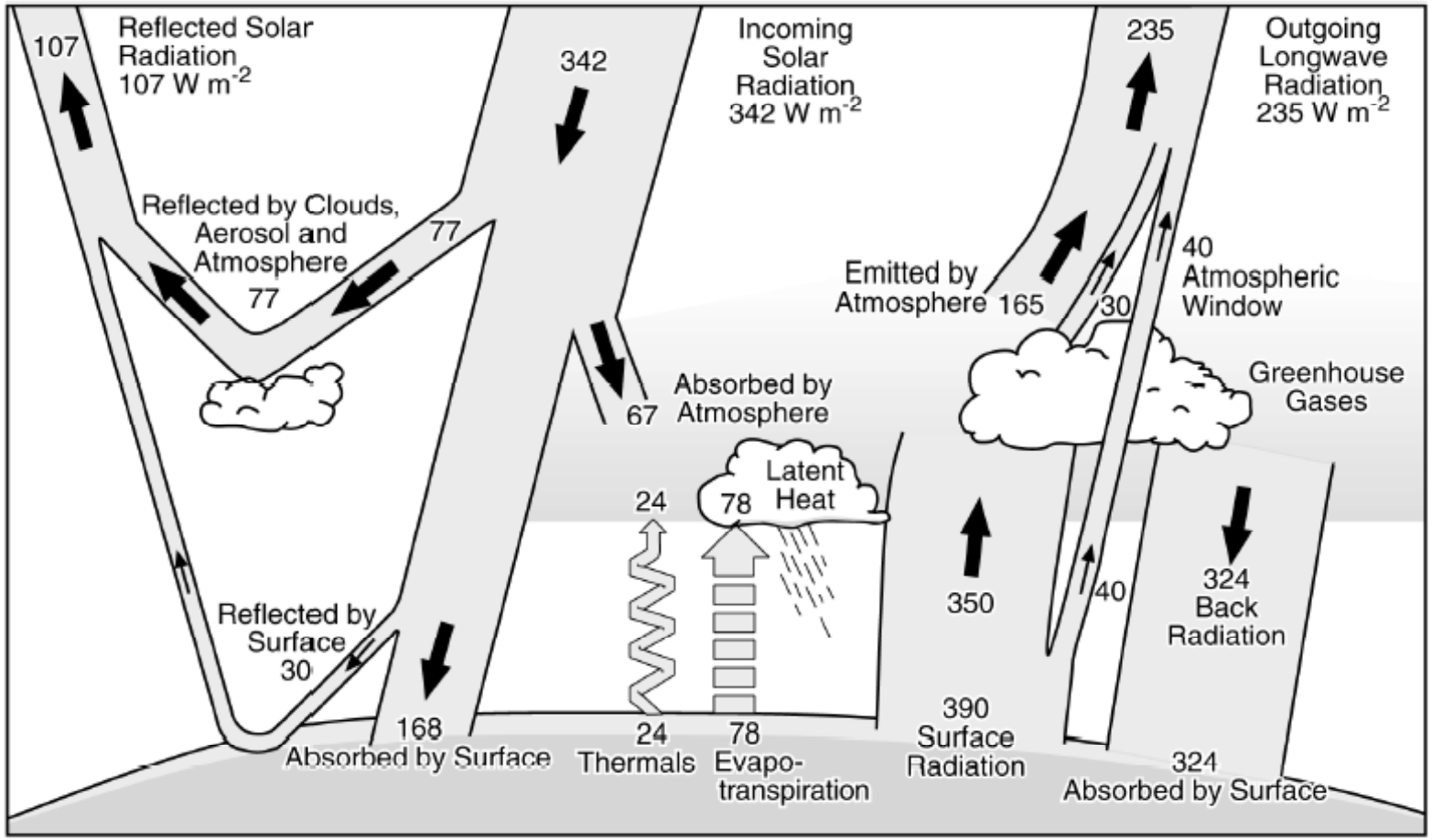
- Cool roofs keep buildings cool and reduce cooling energy use
- Cool roofs and pavements reduce summertime temperature, improve ambient conditions, improve air quality, reduce mortality
- Cool surfaces counter global warming
  - Reflective roofs and pavements directly cool the globe, independent of avoided CO_2

Geo-engineering 101

CO_2 offset: Methodology

- Changing albedo of urban surfaces and changing atmospheric CO_2 concentration both result in a change in radiative forcing (RF)
- Comparing these two radiative forcings relates changes in solar reflectance of urban surfaces to the changes in atmospheric CO_2 concentration

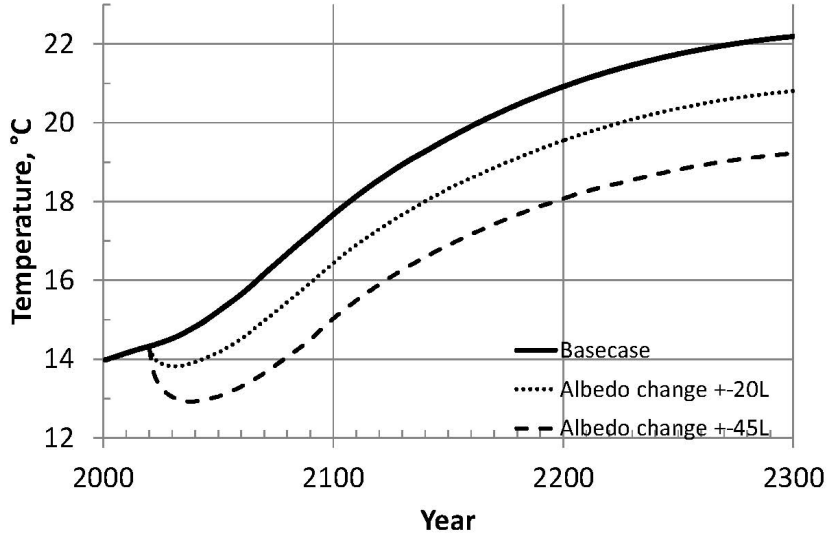
The Earth's radiation budget

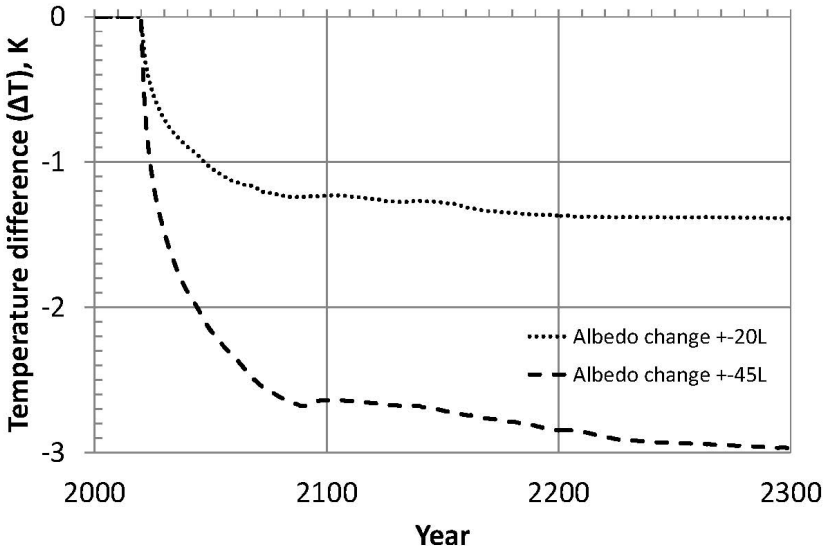


Source: Kiehl and Trenberth, 1997: *Bull. Amer. Meteor. Soc.* 78, 197-208

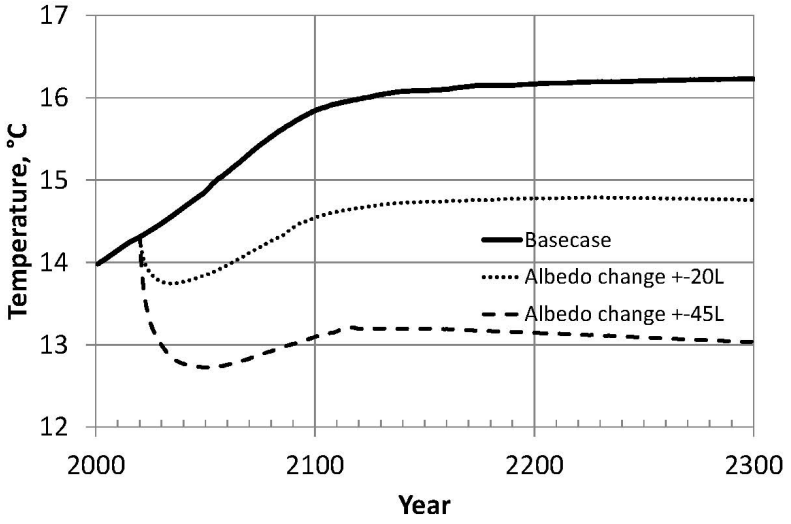
Global temperature change with increased surface albedo over land areas by 0.1 between ± 20 degrees and ± 45 degrees

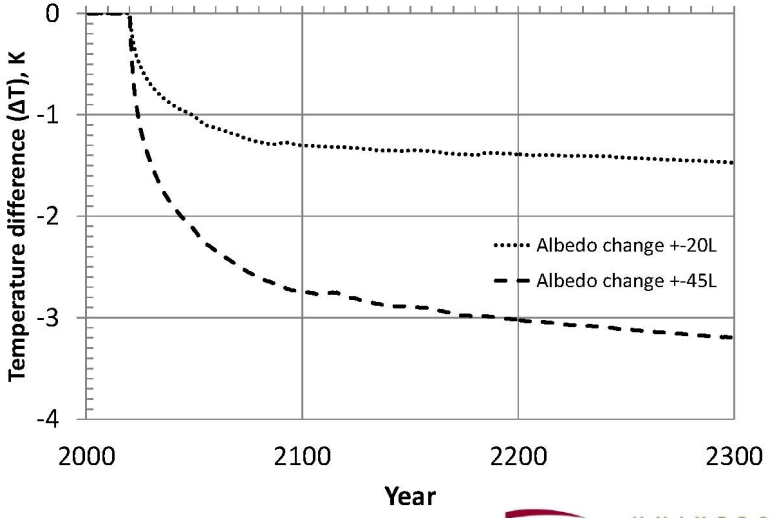
Business-as-usual





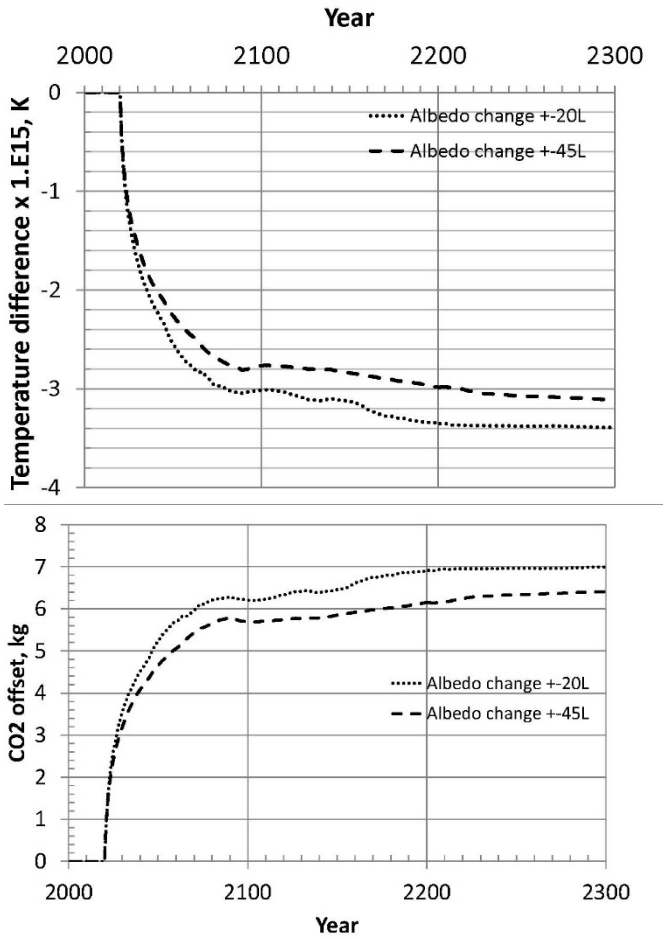
Aggressive mitigation

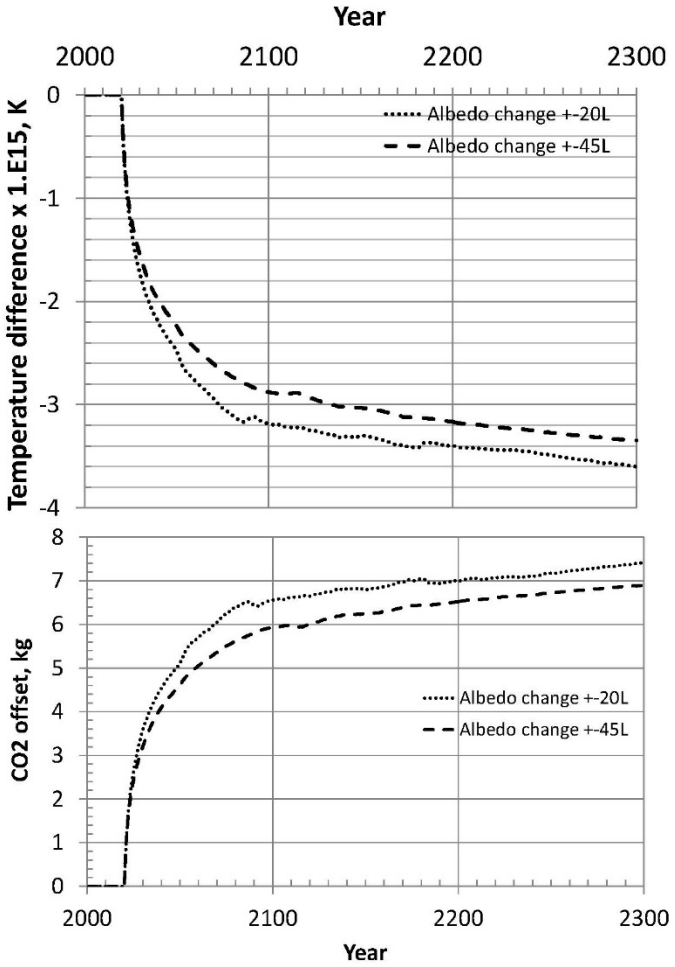




Global temperature change and equivalent CO_2 emissions offset per unit area per albedo increase of 0.01

Business-as-usual





Aggressive mitigation

Increasing albedo of 1 m^2 of a surface by 0.01 decreases the long-term global temperature by ~ $3x10^{-15}$ K, offsetting 6.5-7.5 kg of CO_2 emissions

CO_2 offsets of cool roofs and pavements

- Low-sloped roofs
  - Δ albedo for aged white roofs = 0.40
  - Emitted CO_2 offsets for white roofs = -280 kg CO_2/m^2
  - It takes about 4 m^2 of white roof to offset 1 t CO_2 emitted
- Sloped roofs
  - Δ albedo for typical residential and non-residential cool roofs = 0.25
  - Emitted CO_2 offsets for cool roofs = -170 kg CO_2/m^2
- Pavements
  - Δ albedo for cool pavement = 0.15
  - Emitted CO_2 offsets for cool pavements = -100 kg CO_2/m^2

Source: Akbari et al. 2012: *Environ. Res. Let.* 7(2).

World-wide CO_2 offset of cool roofs and pavements

- Typical urban area is 25% roof and 35% paved surfaces
- World-wide urban areas = 1.5×10^{12} m^2 (1.5 M km^2)
- World-wide roof area = 3.8×10^{11} m^2 (0.38 M km^2)
- World-wide paved area = 5.3×10^{11} m^2 (0.53 M km^2)
- Emitted CO_2 offset for cool roofs = 67 GT CO_2
- Emitted CO_2 offset for cool pavements = 56 GT CO_2
- Total for cool roofs and cool pavements = 123 GT CO_2

- Note:
  - Akbari et al (2009) estimate 44 GT CO_2
  - Menon, Akbari et al (2010) estimate 57 GT CO_2
  - Akbari and Matthews (2010) estimate 78 GT CO_2
  - Akbari et al (2012) estimate 150 GT CO_2

CO_2 offset of cool roofs and pavements

- 150 Gt CO_2 is over 4 years of the world 2025 emission of 37 Gt CO_2
- At a growth rate of 1.5% in the world's CO_2-equivalent emission rate, 150 GT CO_2 would offset the effect of the growth in CO_2-equivalent emissions for 25 years
- Would offset emissions from all cars for 60 years

Value of CO_2 offset

- CO_2 emissions currently trade at ~$25/tonne
- 150 Gt worth $3,700B, for changing albedo of roofs and paved surfaces
- Cooler roofs also save air conditioning (and provide comfort) and improve air quality worth over $5,000B over the next 100 years

Global Cool Cities Alliance (GCCA)

- Non-profit international cooperation launched in 2010
- Mission: Advance policies and actions to increase solar reflectance of urban surfaces to
  - Cool buildings
  - Cool cities
  - Cool the world
- Membership: Open to all cities in the world

GCCA Partners

- Cool Cities
  - Working with New York, Chicago, Taipei, Athens, Singapore, San Francisco and others
  - Partnership with C40 – 60 large global cities
- Regional Governments
  - Partnership with R20: Regions of Climate Action. R20 includes 26 state and large city governments from 5 continents.
- National Governments
  - Operating Agent for Clean Energy Ministerial GSEP Working Group
  - Developing public/private partnerships for deployment.
  - Full members include India, Japan, U.S., Mexico. Observers from Brazil, Russia and South Africa.

Conclusion

Steve Ackerman and Jonathan Martin, **Ask the Weather Guys: What is the status of the ozone hole?** *Wisconsin State Journal*, 6 Oct. 2014**.**

"*Thanks to the Montreal Protocol's phased global ban on chlorofluorocarbon (CFC) use and the natural decay of these chlorine compounds, the stratosphere will be CFC-free near the end of the 21st century. In their absence, the ozone layer will repair itself naturally.*

The good news is that the size of this ozone hole is showing signs of shrinking. This recovery is a prime example of the power of employing science research in the shaping of public policy.

We would be wise to learn from this example to inform our collective approach to climate change."

Conclusion

We can and will make a difference

- We are the world
- We are the cool
- We have made it happen
- We will continue to make it happen