It is Arrogant or Blasphemous to think that Humans Can Change the Weather or Climate?

Ozone hole: early skepticism, then Action with Montreal protocol
CLIMATE AND CITIES:
THE SCIENCE AND THE CHALLENGE OF COMMUNICATING THEIR INTERACTIONS

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Director, UGA Atmospheric Sciences Program and Professor of Geography
President, American Meteorological Society
Urban Effects, Do you Consider Them?

- How many of you consider urban effects in your forecasts beyond the Heat Island or a Code Red Air Quality Day

Map showing Dewpoint Forecast 5:00 pm Today.
How Would You Have Explained These Thunderstorms in Atlanta?
More people live in cities, globally, than rural areas.

65-80% by 2025
What Am I Talking About Today?

- Introduction
- Examples of Urban Effects on Weather/Climate
- Is Urban Flooding Increasing?
- What’s the deal with Urban Tornadoes?
- Thoughts on Communicating Threats in Urban Markets
- Closing Thoughts
How Does Urbanization Affect Climate? It’s Way more than UHI!

Global urban land-use trends and climate impacts
Karen C Seto$^1$ and J Marshall Shepherd$^2$

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<td>Various pathways for urbanization to impact the climate system (see text for references)</td>
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Inter-relationship
Urban to Global and back!

Urban effect on climate

- Urban
- Local
- Regional
- Global

Climate impact on urban areas.
Pollution and Ozone
Cities are Carbon Domes
UHI + GHG = A problem

Work of Brian Stone, Georgia Tech
Urban warming outpacing rural warming

Urban areas, on average, are about 0.8°C warmer than rural areas.

Courtesy Brian Stone/Ga. Tech
The Urban Rainfall Effect in a Climatology

Mote, Shepherd, and Lacke 2007 used a radar climatology of warm season rainfall.

Mountain forcing

Atlanta forcing

Inland penetration of Sea Breeze, irrigation (?)
Not just Initiation, but Enhancement

BASE REFLECTIVITY
KMPX - MINNEAPOLIS, MN
06/05/1999 20:27:12 GMT
LAT: 44/50/56 N
LON: 93/33/53 W
ELEV: 1059.0 FT
MODE/VC: A / 11

ELEV ANGLE: 0.50 °
MAX: 56 dBZ

Legend: (Category) dBZ

(15) 75
(14) 70
(13) 65
(12) 60
(11) 55
(10) 50
(9) 45
(8) 40
(7) 35
(6) 30
(5) 25
(4) 20
(3) 15
(2) 10
(1) 5

Courtesy K. Blumenfeld

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Urban downwind lightning, Power Plant Anomalies?

Could the other lightning “hotspots” (red circles) be related to Power Plants (Orville et al. 1981) suggested that power plant effluent could affect storms. Effluent/dynamics from volcanoes produce lightning.

Sources: Marshall Shepherd, Michael Lewis, Stallins and Rose 2008, Southern Co. website
Hypothesised causes

Previous research (see Shepherd 2013, Shepherd et al. 2010, Shepherd 2005 for reviews)

a. Atmospheric destabilization through the enhanced thermal mixing due to low-level heating (i.e., Urban Heat Island (UHI))
b. Increased turbulence and mechanical mixing due to increased aerodynamic roughness created by tall buildings
c. Modified microphysical and dynamic processes caused by the addition of aerosols from automobiles and industry
d. Bifurcation of pre-existing precipitating systems by physical or thermodynamic processes
Atmospheric destabilization

Heating from below modifies the vertical temperature profile increasing the environmental lapse rate, making the atmosphere less stable.

In circumstances where the regional airflow is very weak, a strong urban heat island could produce convergence over the city.
City Landscapes Communicate With The Atmosphere
Roughness, turbulence & convergence

Characteristics III: Wind effects - building scale

- Increased friction and heat result in perturbations of wind and turbulence
- Vortices, turbulent wakes and cavities are typical characteristics of flow around buildings.

Characteristics III: Wind effects - city scale

The city is one of the roughest surfaces known and as a whole affects regional flow:

- Weak winds: Thermal effects dominate - in-flow towards warm city
- Strong winds: Convergence causes uplift over city

(From Oke 1993) (From: http://www.meteorological.com/Resc-english/Tac/Airshou4.html)
The aerosol effect is not simple and may serve to either enhance or depress precipitation from an individual event.

(Rosenfeld et al. 2008; Jin and Shepherd (2009); van den Heever and Cotton (2007))
The turbulent urban atmosphere causes a disruption of mesoscale and synoptic weather fronts. The diagram above shows thunderstorm cells splitting around New York city. (following Bornstein and colleagues, AGU, Niyogi et al. 2011)
Pork or Beef Snow?

NWS Dodge City Area (January 2011) documented localized “downwind” snow attributed to Animal Slaughter Houses and Power Plants (Shepherd and Mote 2011, Earthzine)
Are urban floods increasing?

**SOUTHERN ALBERTA FLOODING**

- Mumbai 2005
- Atlanta 2009
- Calgary
  - Dozens of homes under mandatory evacuation
  - Flooding and mudslides force the closure of the Trans-Canada Highway
  - As many as 100,000 people could be forced from their homes due to heavy flooding
  - Flooding and a sour gas leak cause evacuations
  - Flooding forces evacuations
  - Some evacuations with river expected to rise

Nashville 2010

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Increasing Flood Risks (FEMA 2013, Andersen and Shepherd 2013)

Climate change could:

- increase the areas of the United States at risk of floods by up to 45% by 2100.
- double the number of flood-prone properties covered by the NFIP.

% Change since 1950 in Top 1% Heaviest Rainfall Events (NCA, 2013)
New research by University of Georgia, University of Oklahoma, and the National Weather Service has revealed potentially predictive relationships between precipitable water (PW) distributions and urban flooding. Schroeder et al. (2013):

• 37 major U.S. major urban flood events studied (1973-Present)
• Events associated with extremely anomalous precipitable water (column integrated water vapor) values (PW)
  • 29 had PW values above 2 standard deviations from the mean. 20 of which were above the 99th percentile (5 were at/near max value)
  • 8 cases had PW values above 75th percentile,
• a “composite” flood sounding of 37 events has characteristically tropical structure.

Fig. 2. Recent example from FLASH identifying flood event in VA (June 2013). Pink is > 95% PW in flood region
What about Urban Tornadoes?

- Wurman et al. 2007

“The areal extent of cities and surrounding densely populated suburbs is growing and it is inevitable that someday a large, intense, and long-track tornado will impact a densely populated urban or suburban region.”
Tornado Tracks, Past 56 years
Here is every tornado that caused more than $50 million in property damage. Urban?
Atlanta’s Growth: Increases Probability of Urban Tornado (Bigger Dart Board!!!)

1974

2005

Our initial research leads to the question of whether GEMA or the city of Atlanta should re-evaluate urban warnings (e.g. implementation sirens)

Landsat Images: UGA School of Ecology/NARSAL
Tornado Initiation Points (1950-2010) from C. Doswell
Urban Coastal Threats?
Coastal Cities and Hurricane Return

Keim et al. 2007
Sandy deaths: Example of Communication Challenges and Vulnerability

Cause of Death

- Hypothermia
- Blunt force trauma
- Drowning
- Tree fall
- Carbon Monoxide poisoning
- Fire related
- Other

Hurricane Sandy Related Fatalities

Primary Source: New York Times

Date Processed and Layout Designed by: Craig Ramseyer, Yanti Wang, and Jasmine Yanez

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Figure 8. Fatalities that occurred inside the storm surge buffer (red triangles) and other fatalities outside the storm surge buffer (black circles).
Communicating Urban Weather Climate Hazards

- Cross-disciplinary teams that include natural scientists, decision scientists, social and communications specialists and other experts. (Fischhoff and Pidgeon)
  - People respond to warnings differently
  - Language and Intellect Barriers
  - Capacity to Respond
- Rather than avoiding communicating uncertainty altogether, science communicators should make an effort to understand beliefs held by the recipients of their messages. (Rabinovich 2012)
- Rather than simplifying and reframing scientific messages in an attempt to make them acceptable for the general public, communicators might consider shaping their audience’s understanding of what science actually is (Rabinovich 2012)
- People are able to make better decisions using probabilities. People make the best decisions when they are given more detailed information on forecast uncertainty (UK Met Office)
- Market Hype and Recent History (Recent DC Derecho)
- Perception of One Threat vs Another (Tornado, Flood, etc.)
Climate Vulnerability with Place-Based Vulnerability (Kc and Shepherd, 2013)

Vulnerability is a function of exposure, sensitivity, and adaptive capacity.