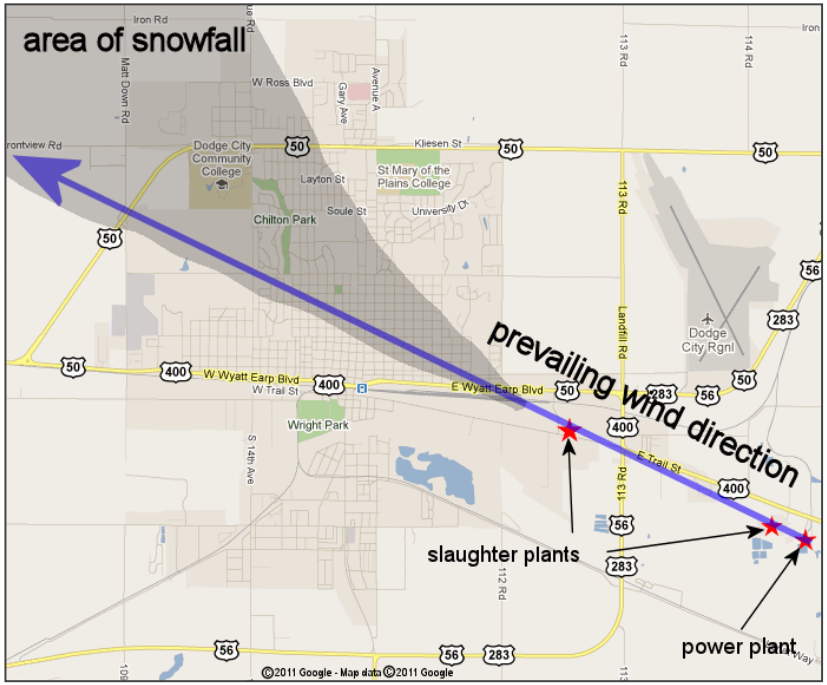
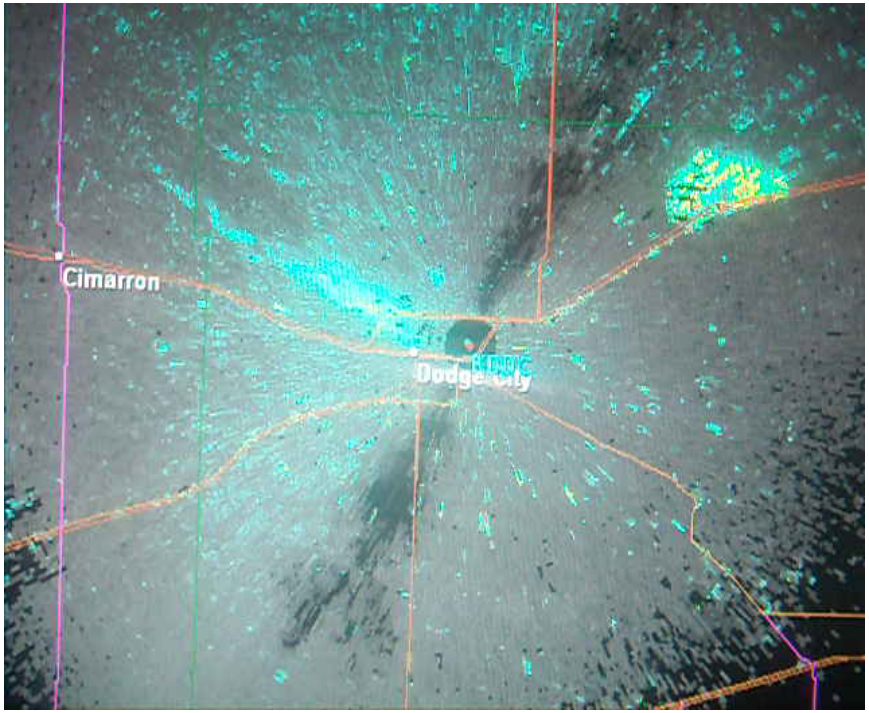
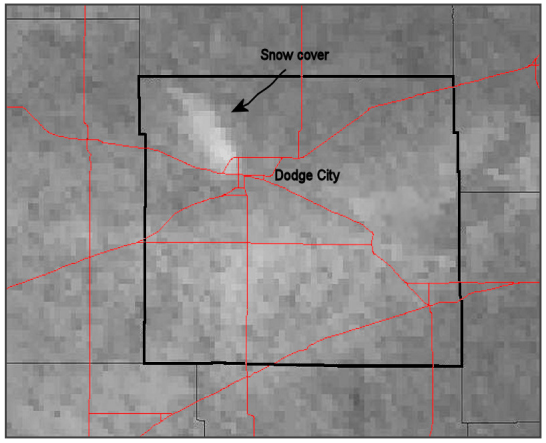
Pork or Beef Snow?







NWS Dodge City Area (January 2011) documented localized "downwind" snow attributed to Animal Slaughter Houses and Power Plants (Shepherd and Mote 2011, Earthzine)

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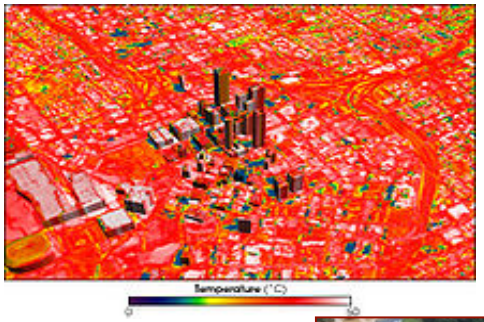
Current and Emerging Perspectives on Urban Precipitation-Storm-Relationships



Dr. J. Marshall Shepherd

Professor, Research Meteorologist, Department of Geography,

http://www.ggy.uga.edu/people/faculty/marshgeo/Welcome.html

Director, UGA Atmospheric Sciences Program, http://www.uga.edu/atsc/

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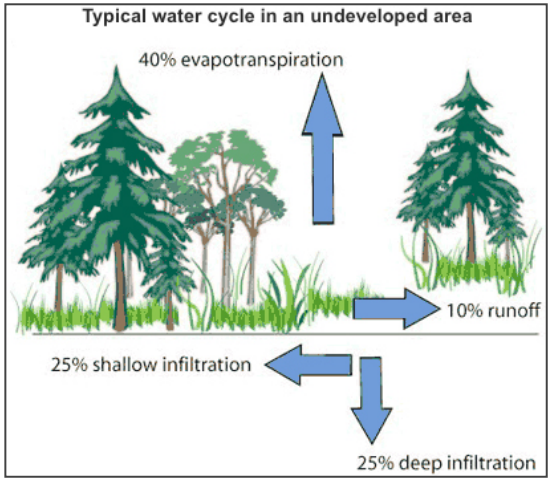
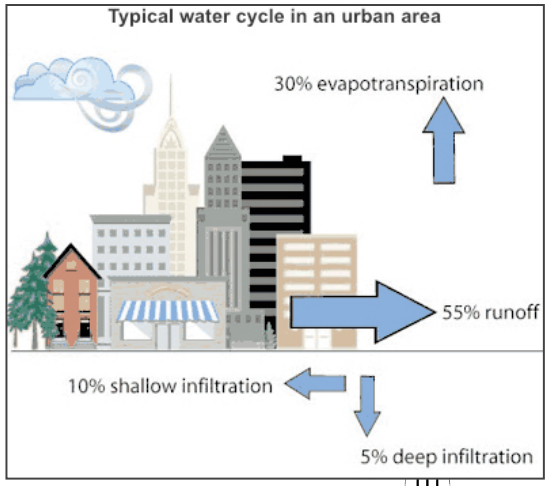
NASA

Urbanization and Hydroclimate

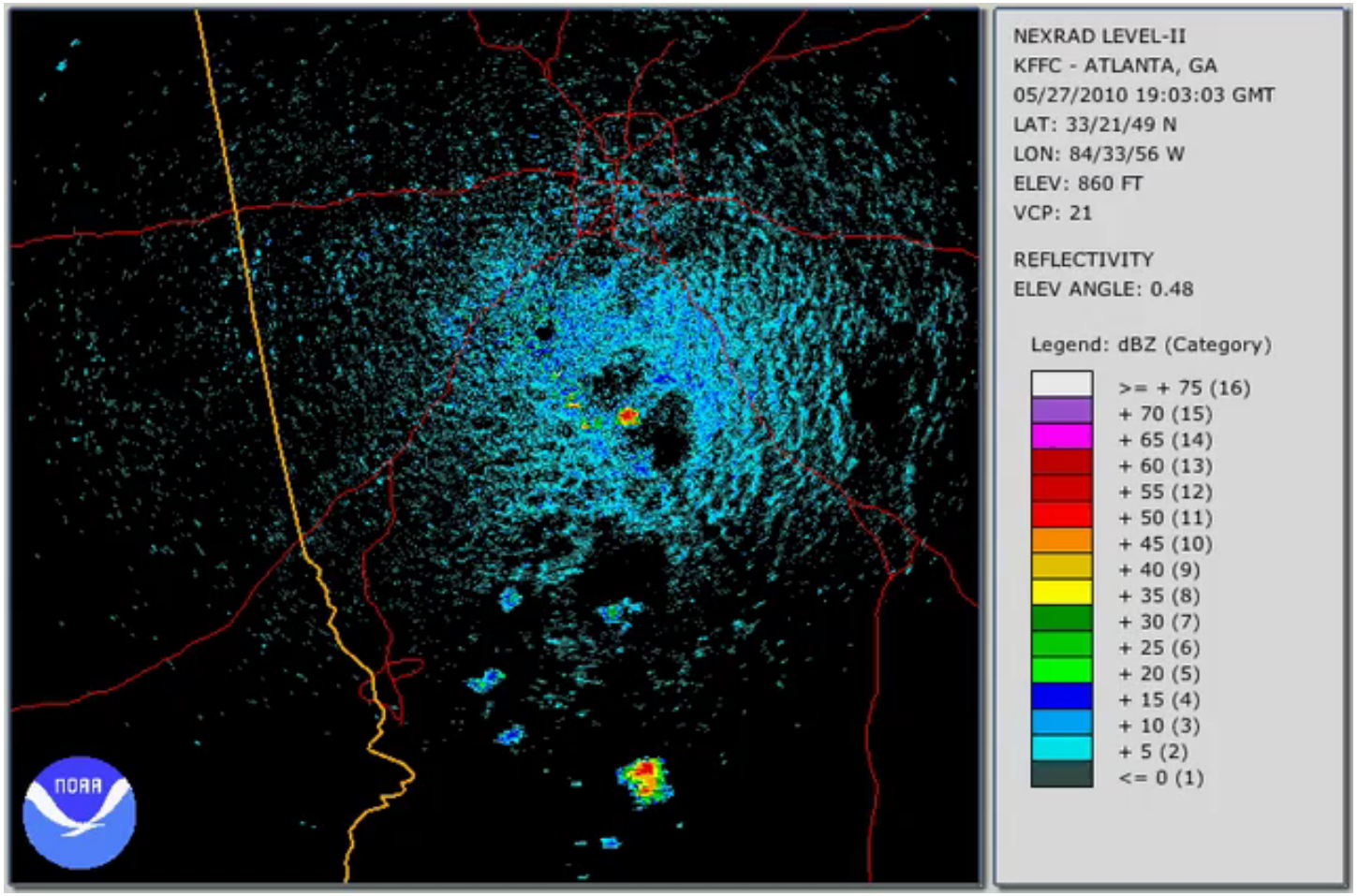
- Increased heavy rain events (Bates et al. 2008, IPCC 2007, Groisman et al. 2004)
- Shepherd et al. (2011) and Burian et al. (2004a) discussed the implications of urban-induced precipitation on the design of urban drainage systems.
- Current NASA IDS RFP is Urban Focused
- PI Shepherd recently on National Academies Study on Urban Meteorology
- Voters live in Cities. They notice urban rainfall extremes and floods. Majority of people now live in cities (80% by 2025)

Where is Precipitation below?





Storms Being Initiated By Atlanta



Urban Effects on Precipitation: Global Not Isolated

Paris, Multiple European Cities: Thielen et al. 2000, Trusilova et al. 2008, Freud 2008

China: Jin, Shepherd, and King 2005, Jin and Shepherd 2009, Meng et al. 2007, Kaufmann et al. 2007, Zhang et al. 2007, Guo et al. 2006, Jin and Shepherd 2008, Zhang et al. 2008, Zhang et al. 2009

Atlanta, St. Louis, Phoenix, Houston, Baltimore, Dallas, Oklahoma City, Indianapolis St. Louis, New Jersey Fairbanks: Bornstein and Lin 2000, Shepherd et al. 2002, Rozoff et al. 2003, Burian and Shepherd 2003, Shepherd et al. 2004, Molders and Olson 2004, Dixon and Mote 2003, Diem and Brown 2003, Burian et al. 2004, Diem and Mote 2005, Burian and Shepherd 2005; Shepherd 2006, Niyogi et al. 2006, Mote et al. 2007, van den Heever and Cotton 2007, Ntelekos et al. 2007, Rose et al. 2008, Diem 2008, Wichansky et al. 2008, Shem and Shepherd 2009, Zhou and Shepherd 2009; Stallins et al. 2009, Bentley et al. 2009; Lacke et al. 200; Pyle et al. 2009), Shepherd et al. 2011

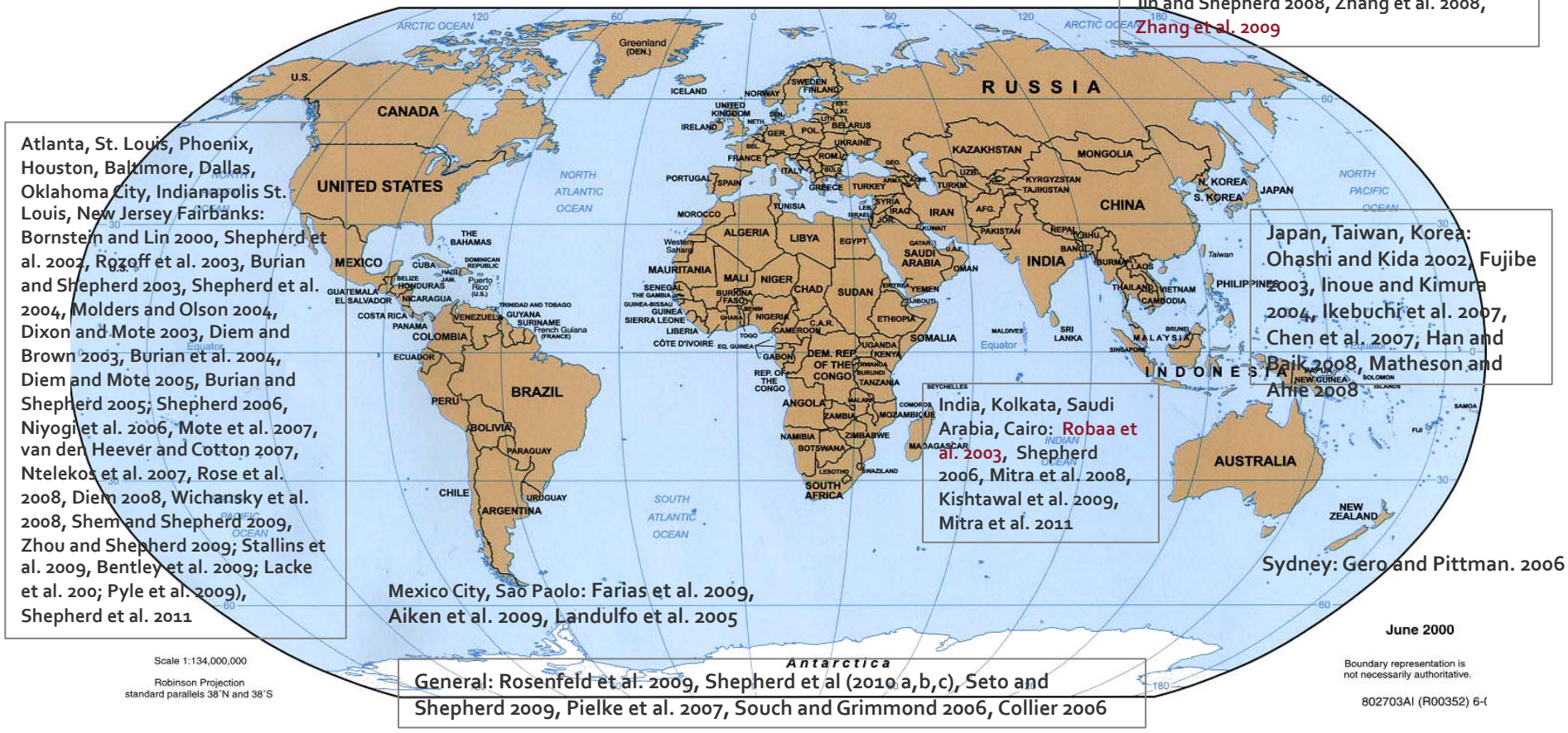
Japan, Taiwan, Korea: Ohashi and Kida 2002, Fujibe 2003, Inoue and Kimura 2004, Ikebuchi et al. 2007, Chen et al. 2007, Han and Baik 2008, Matheson and Ahie 2008

India, Kolkata, Saudi Arabia, Cairo: Robaa et al. 2003, Shepherd 2006, Mitra et al. 2008, Kishtawal et al. 2009, Mitra et al. 2011

Sydney: Gero and Pittman. 2006

Mexico City, Sao Paolo: Farias et al. 2009, Aiken et al. 2009, Landulfo et al. 2005

General: Rosenfeld et al. 2009, Shepherd et al (2010 a,b,c), Seto and Shepherd 2009, Pielke et al. 2007, Souch and Grimmond 2006, Collier 2006



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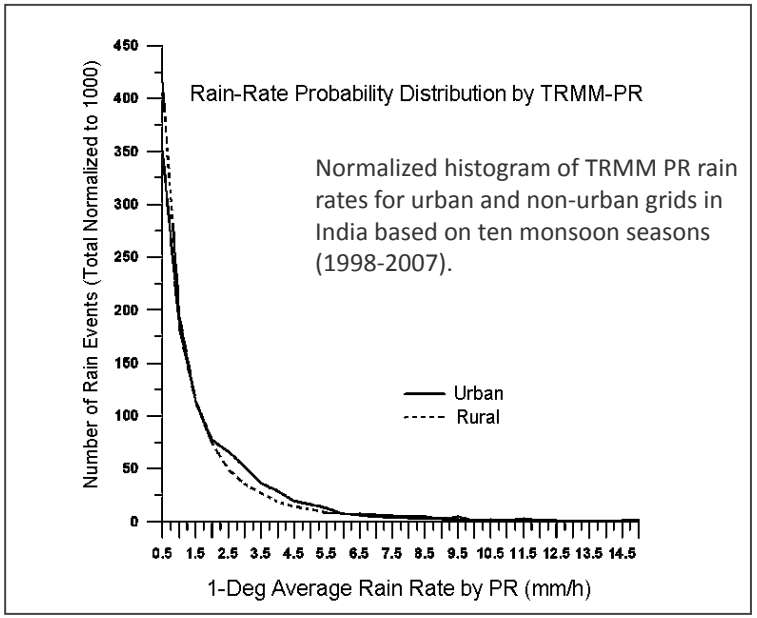
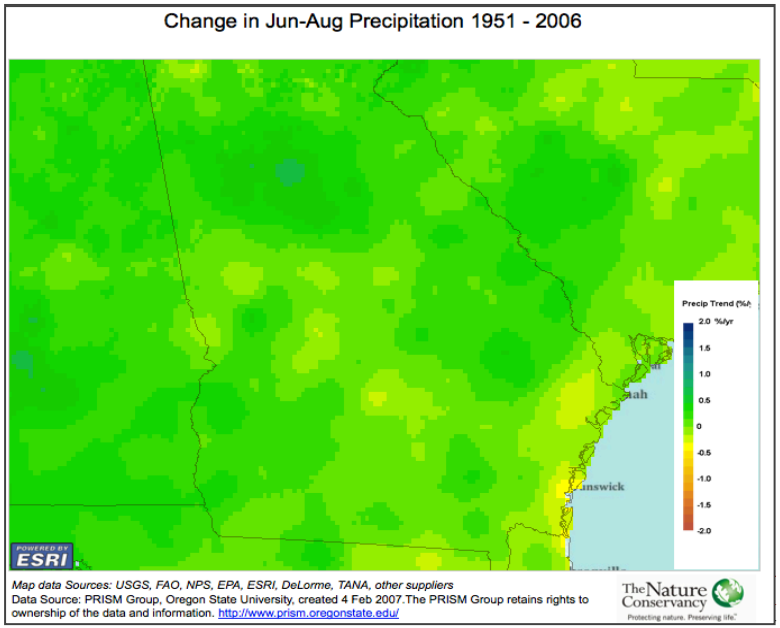
1. Leveraging the lengthening satellite precipitation record

- What are relative contributions of topographical, meteorological geographical, and anthropogenic activities influence the relative roles of urban land cover and aerosols on precipitation processes

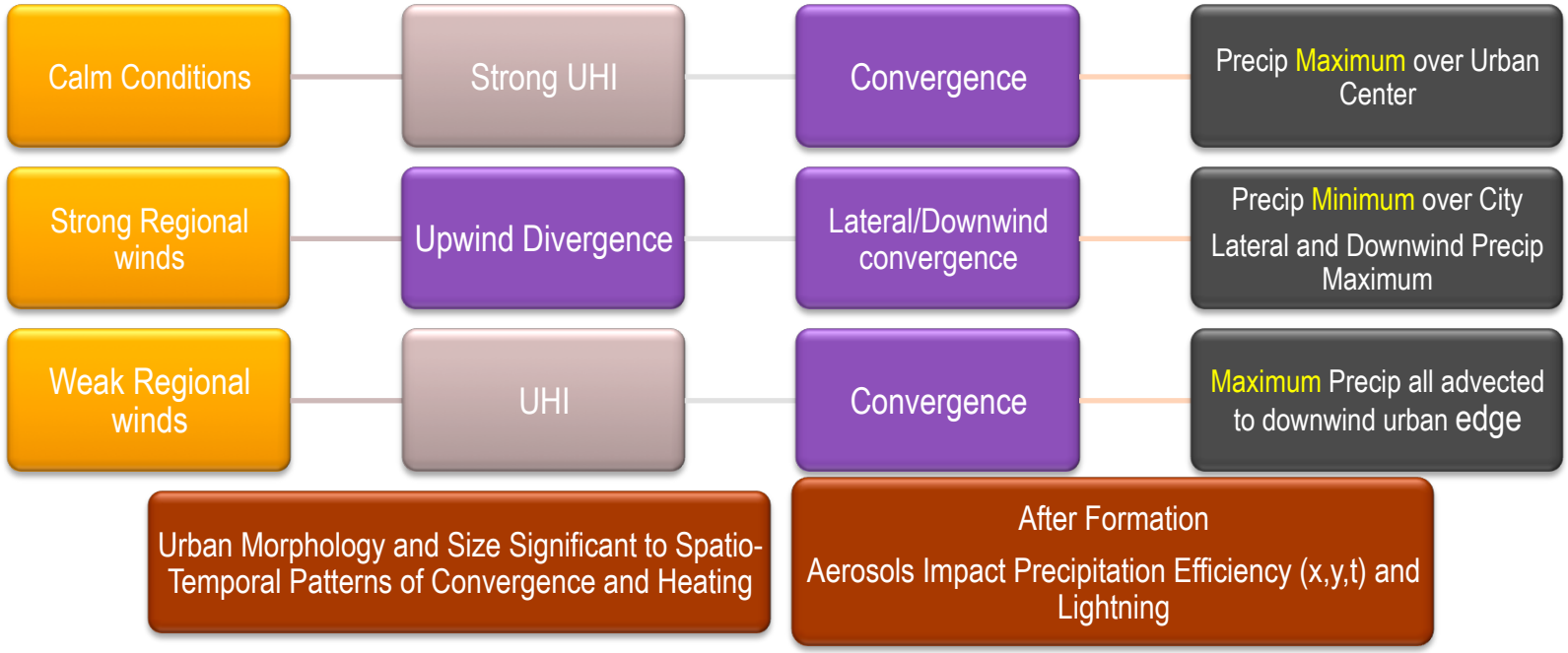
- What highly urbanized geographic regions are more likely to exhibit an urban signature in spatio-temporal precipitation variability?

- Can we develop conceptual models or "rules of thumb" to depict favorable conditions for urban land cover, aerosols, or their combination to initiate or modify precipitation?





Towards a Conceptualization of the Urban Precipitation Effect



Other cross-cutting factors to consider:

Bifurcation-thermodynamic dome or physical barrier dome?

How does urban moisture content (lack thereof) and heat island affect local storm dynamics?

Seasonality?

Diurnal effects?

Topography?

Shepherd, Bornstein,and Grimmond, unpublished

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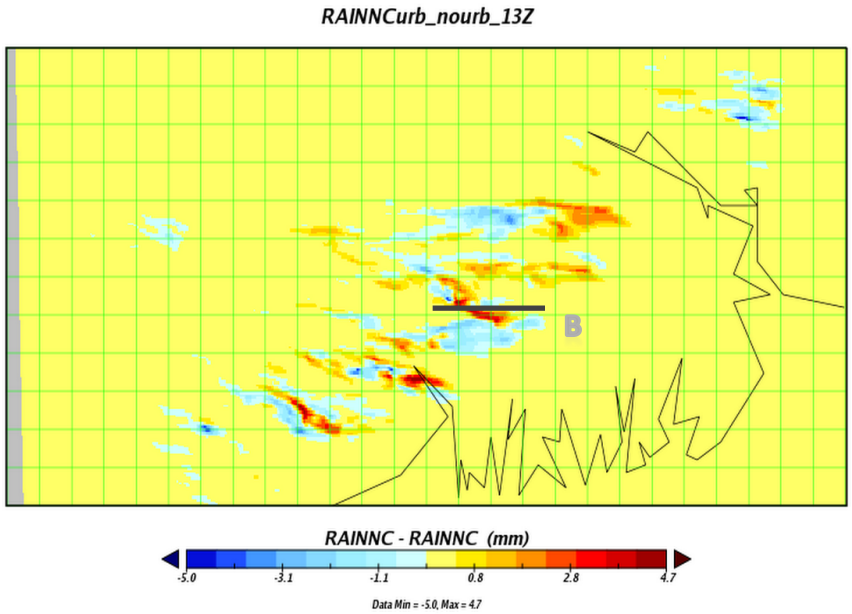
2. Investigating urban land cover-aerosols feedbacks and their role in precipitation formation at convective to regional scales

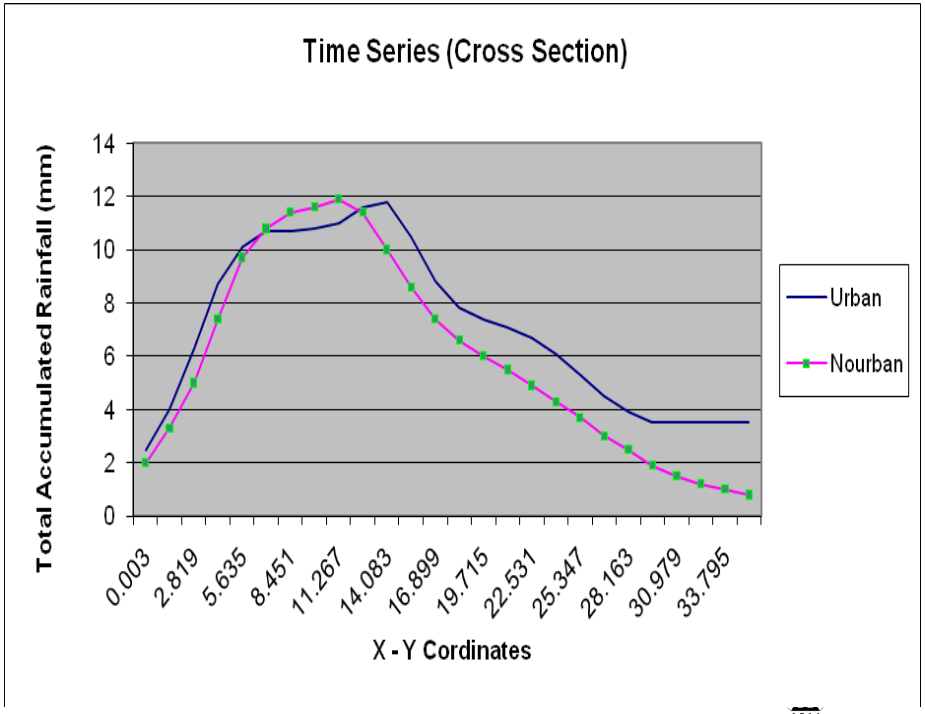
- What role do urban morphological parameters, aerosol, and vegetation and moisture play in precipitation formation, budgets and efficiency?
- Can a coupled modeling system with proper characterization of land cover, aerosols, irrigation, and urban canopy simulate such recycling processes?
- How do such processes scale to affect regional climate, large urban aggregations, or future urban growth scenarios? (Shepherd et al 2010)

Simulation of Urban-Nor'westor Interactions in Kolkta, India



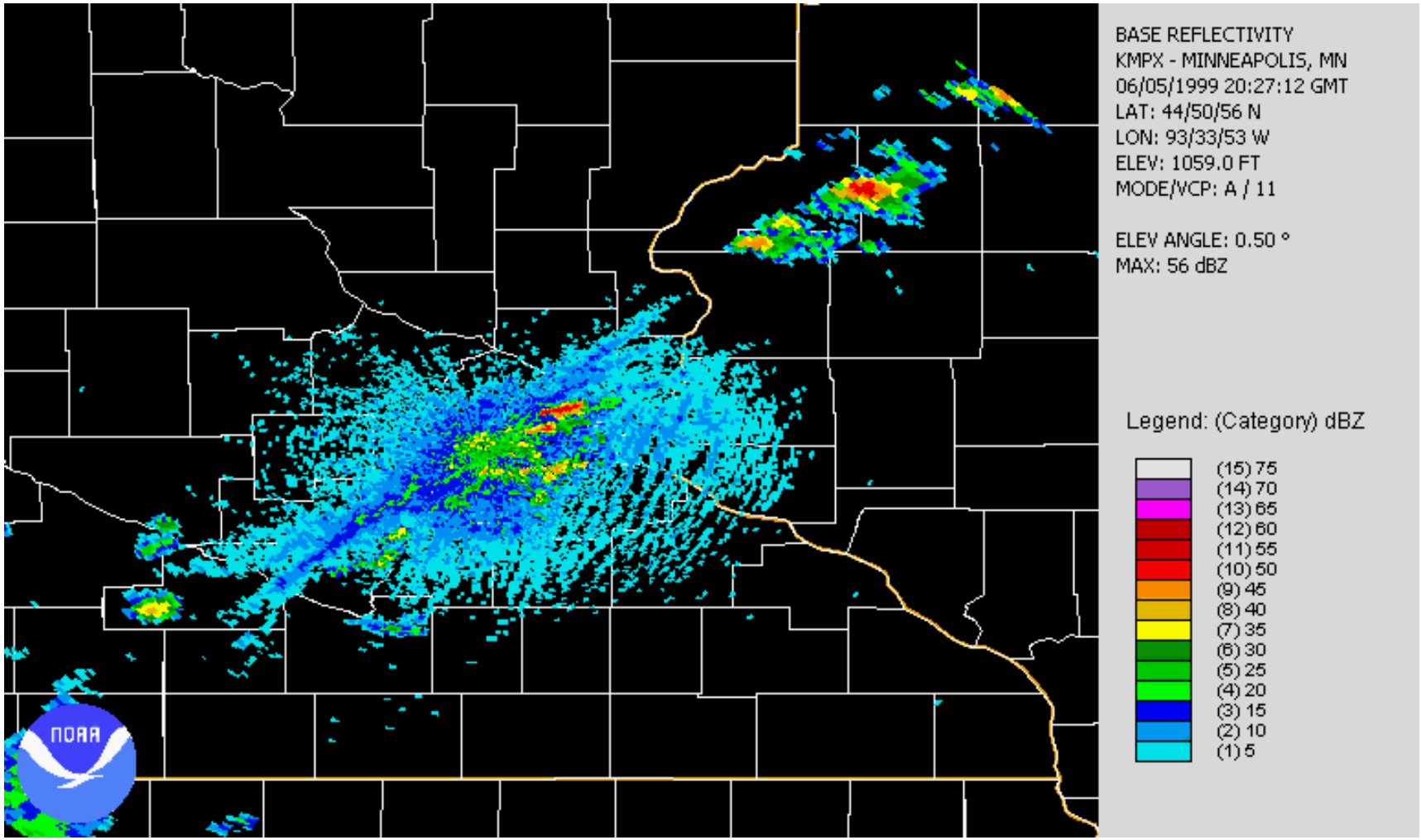
Difference plot of urban minus no-urban scenario: Total accumulated rainfall (mm) on 16th April 2003 at18.30 LST

Time series (cross section) of RAINNC



Mitra et al. (2011), Mitra and Shepherd (2011)

Minneapolis enhancing a convective storm

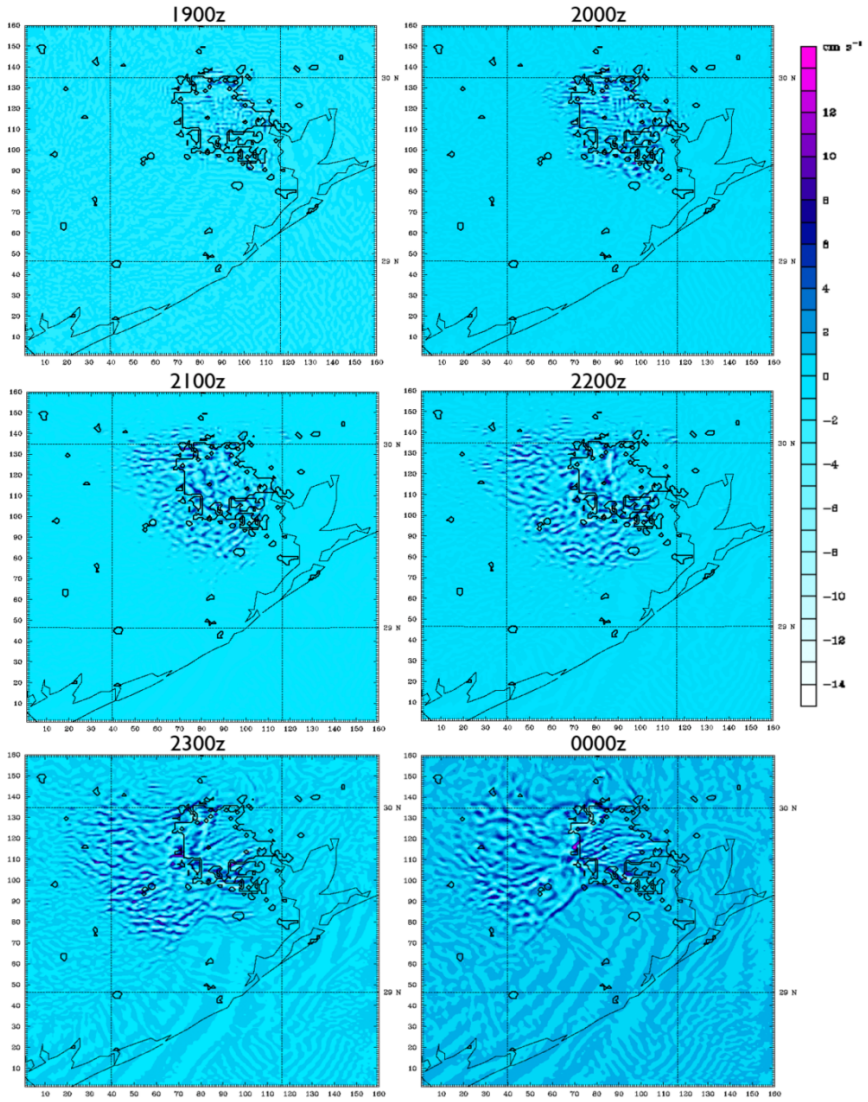


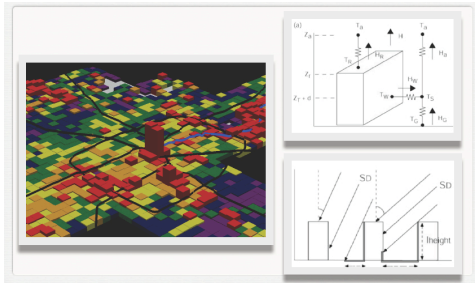
Niyogi et al. (JAMC, 2011) similar findings for Indianapolis

Impacts Urban Morphology on weather models

- Urban WRF difference field in vertical velocity for a control run vs enhanced urban morphological parameters for Houston

- Clearly indicates that there is a different dynamic response which suggests that simulations must represent 3-D Urban Environment (Carter, Shepherd, Burian, and Jeyachandran, 2011, Jtech-A)





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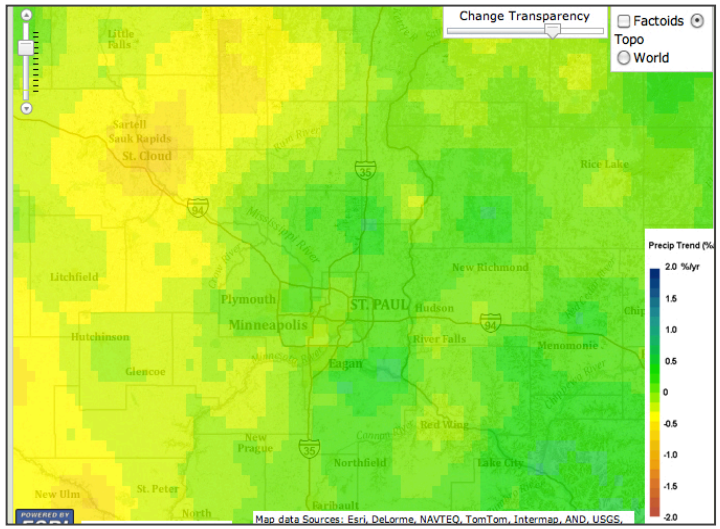
3. Urban effects on frozen precipitation processes and snowfall retrieval

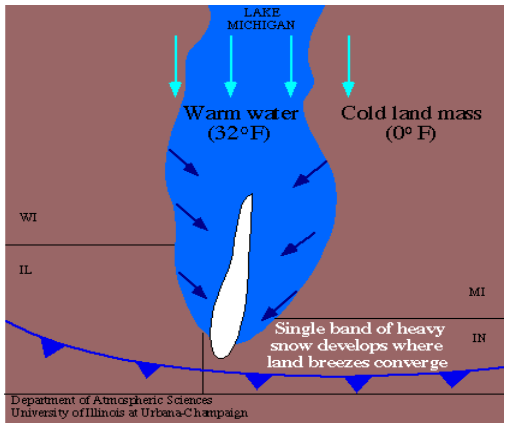
- How do urban aerosols and urban heat islands affect snowfall/ precipitation formation and melt?

- How do urban aerosols and impervious surface affect snowmelt and snowcover on the ground, and are their implications for *snowfall retrieval in the GPM era?*

- Can coupled land surface model and atmosphere model well simulate urban effects on snowfall/ snowmelt and where might they be deficient



Winter (Dec-Feb) Precipitation Trends (1951-2006) for Minneapolis



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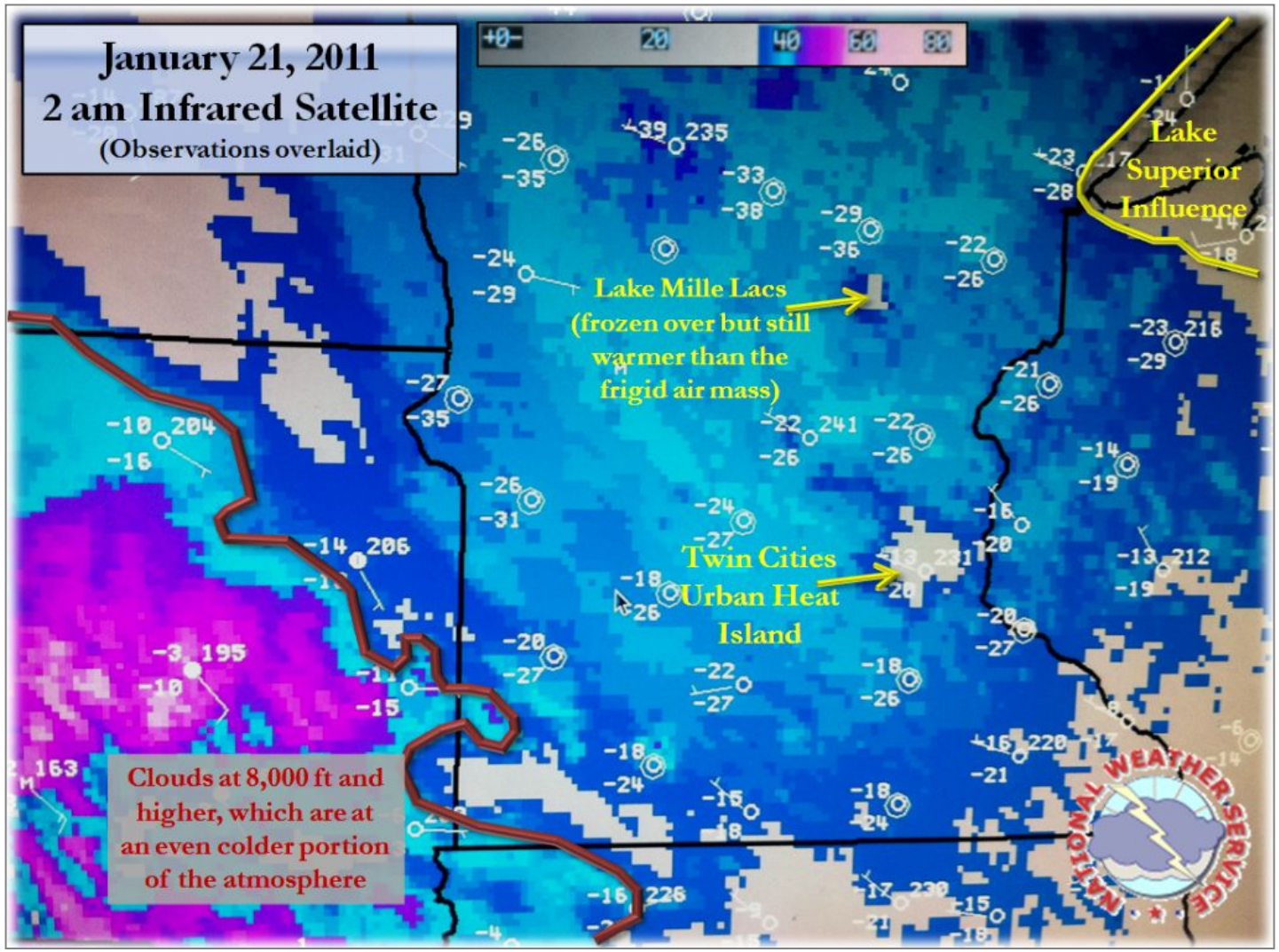
Urban Snow Cover and Melting: Implications for GPM Snow Retrieval (Shepherd and Mote 2011)



4. Coupling urban rainfall effects with hydrological processes

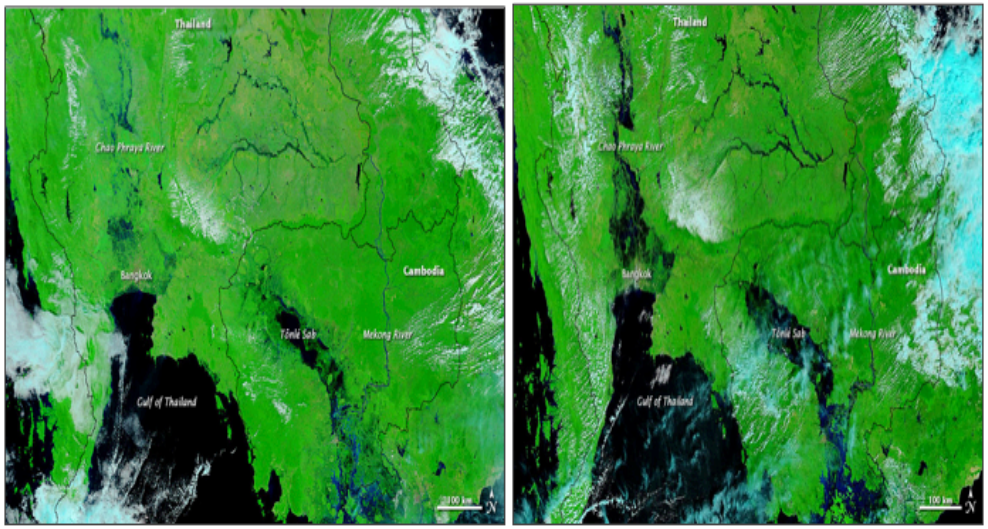
- What is the uncertainty of satellite-based rainfall data in urban areas compared to adjacent non-urban areas and how does it translate to uncertainty of global flood simulation results?

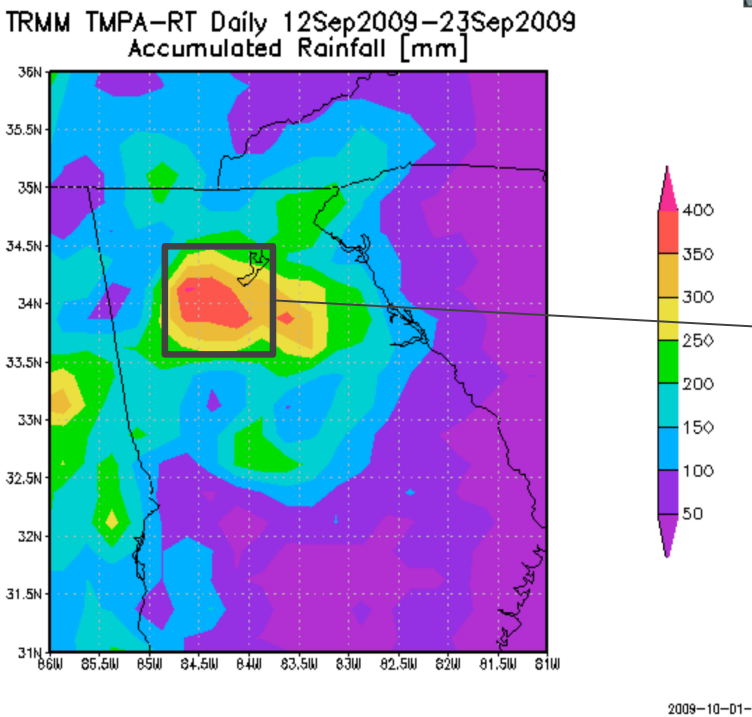
- What is the most computational efficient and accurate method(s) to incorporate urbanization effects and TRMM-GPM era rainfall estimates into global hydrology and flood models?

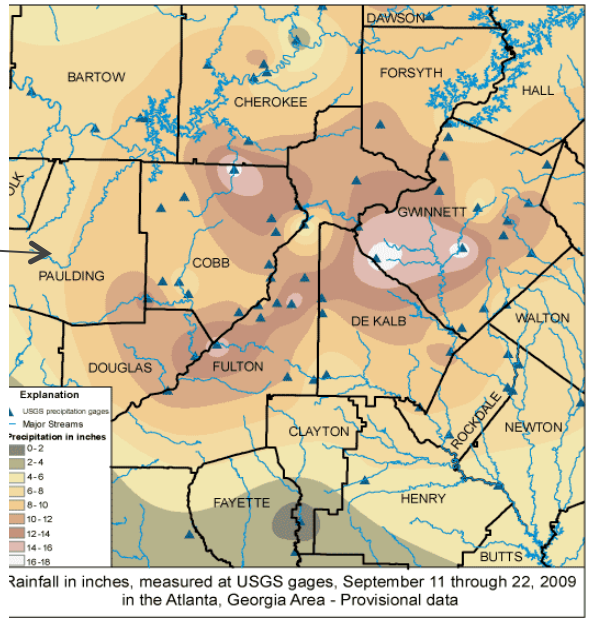
- What are the urbanization effects on water cycle at the river basin scale for global assessment of urbanization and how do we properly quantify them?

Recent Extreme Urban Flooding

2011 Thailand/ Bangkok Floods







2009 Atlanta Floods (Shepherd et al. 2009)

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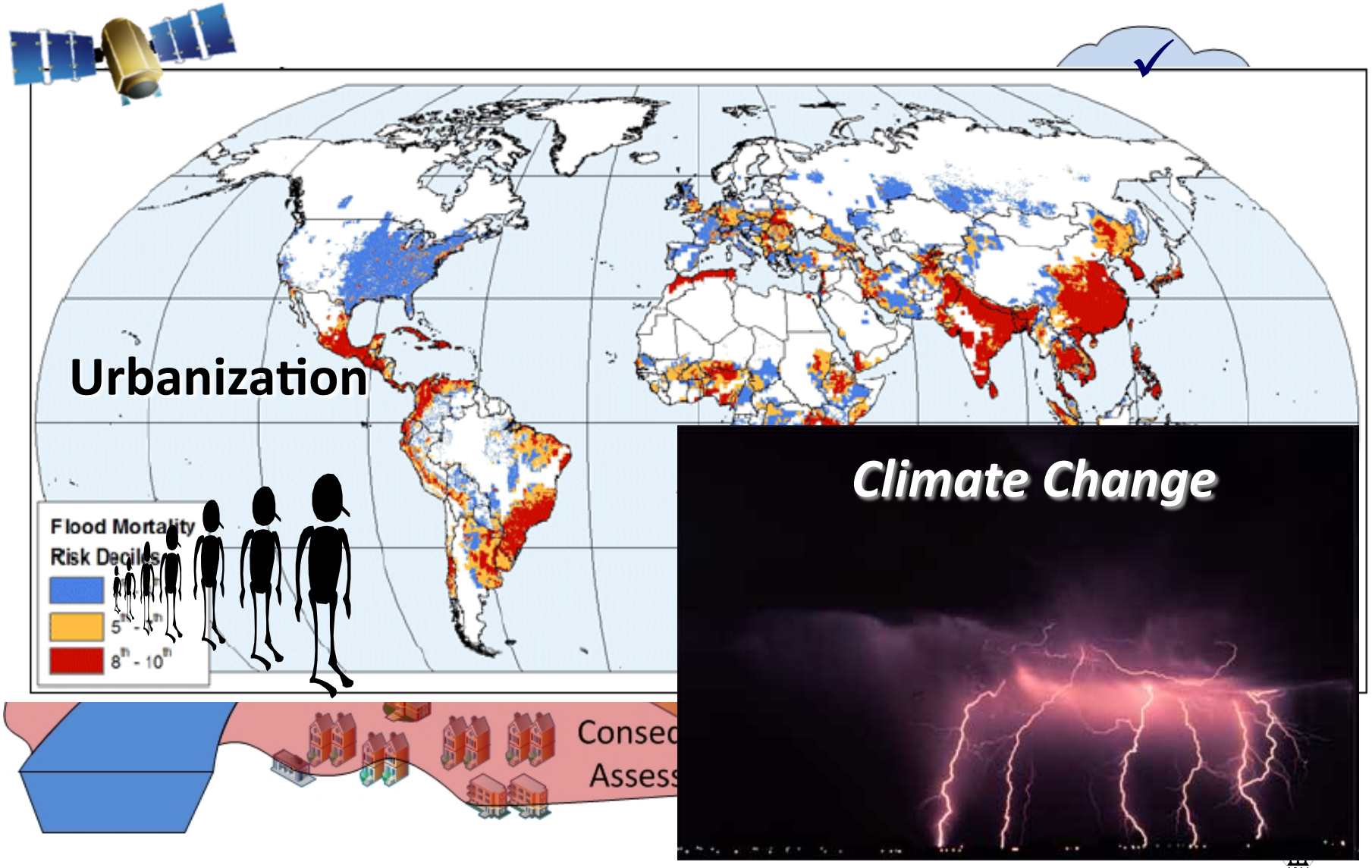
Regional Scale Modeling



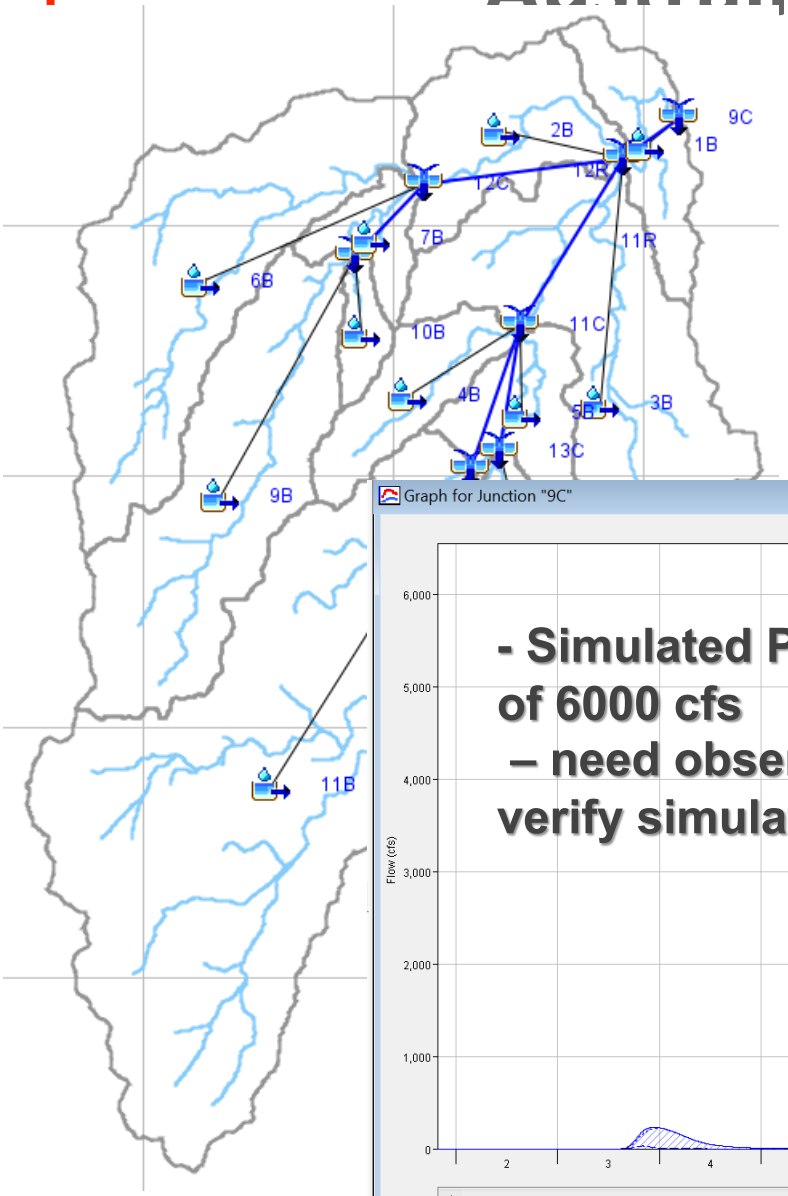
Regional Scale Hydrologic Modeling

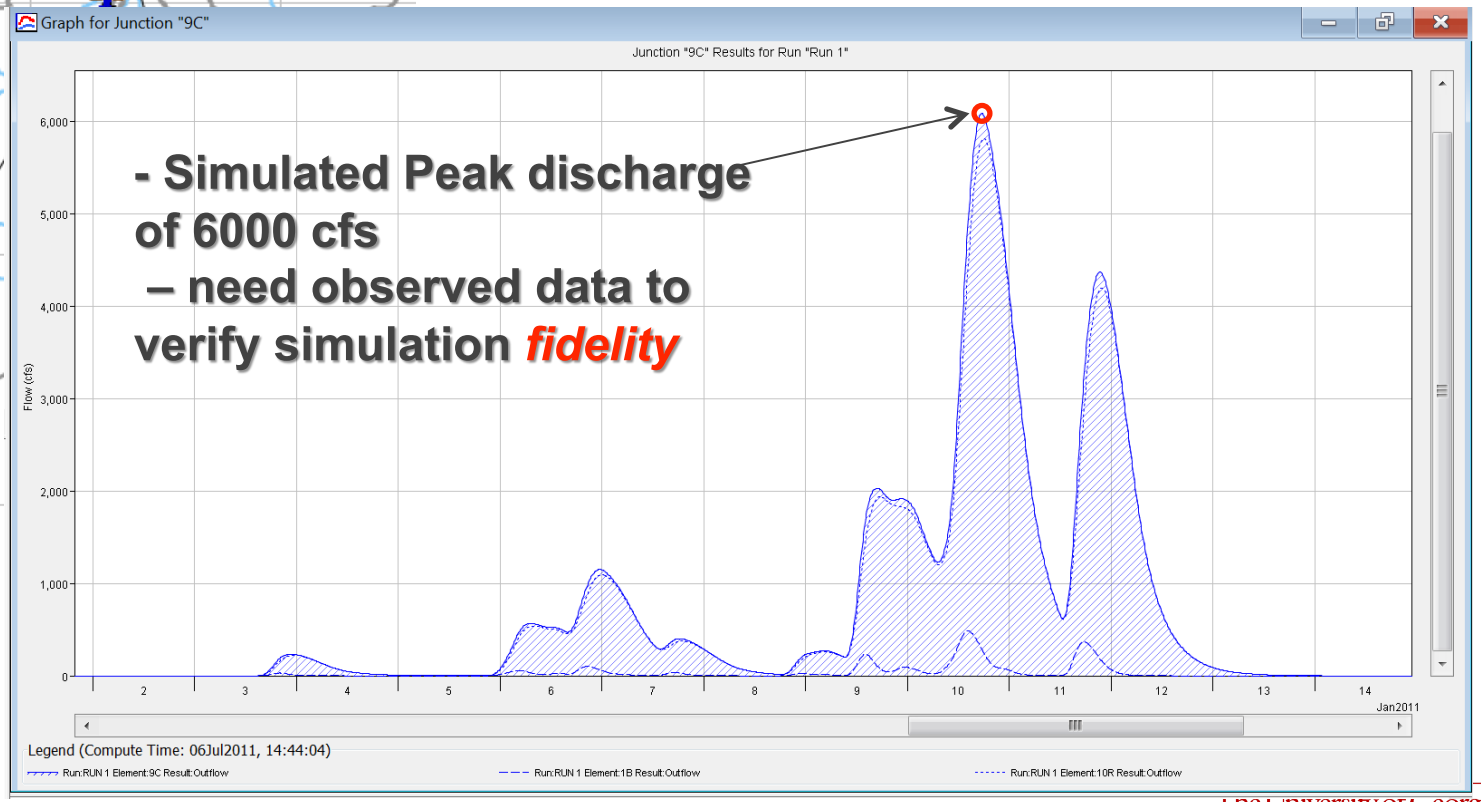
- 4 Case Study Areas – International
- Australia
  - Bremer River Basin (2011 Floods)
- India
  - Ganga Basin (2007 Floods)
  - Krishna Basin (2009 Floods)
- USA
  - Texas (Tropical Storm Allison, 2001)

Australia- 2011 Floods

- Bremer River Basin
  - Ipswich, suburb of Brisbane
  - More than 1100 people affected, significant building damage (Source: Courier Mail, Wikipedia)
- Event Reconstruction Exercise
  - Using TRMM 3B-42 Satellite Product
  - Built HEC-HMS model with gridded precipitation
  - Calibration & Validation – to be done
  - Preliminary Results

Australia

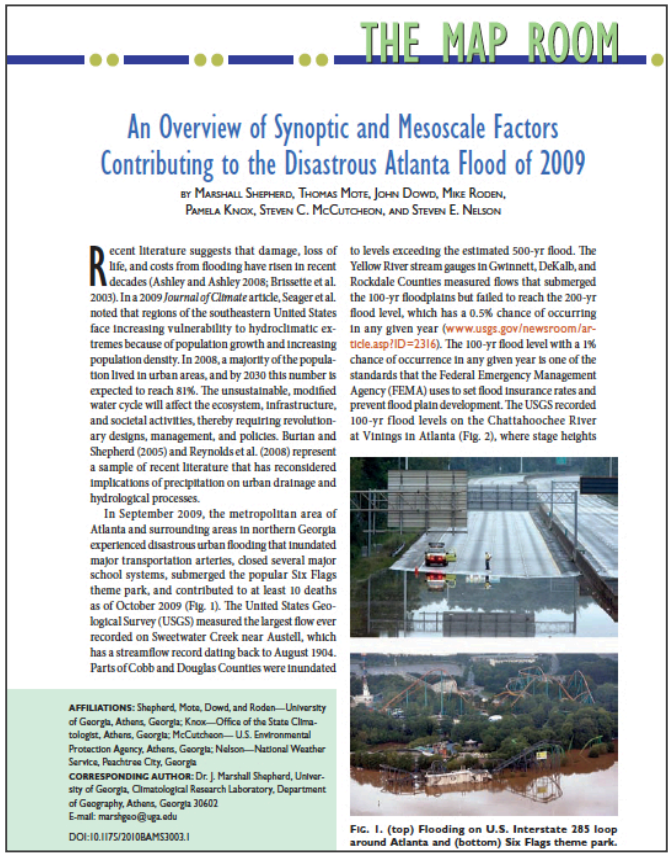




- Simulated Peak discharge of 6000 cfs
  – need observed data to verify simulation *fidelity*

Thanks !

- **Urbanization: The "Other Climate Change"**



THE MAP ROOM

An Overview of Synoptic and Mesoscale Factors Contributing to the Disastrous Atlanta Flood of 2009

BY MARSHALL SHEPHERD, THOMAS MOTE, JOHN DOWD, MIKE RODEN, PAMELA KNOX, STEVEN C. MCCUTCHEON, AND STEVEN E. NELSON

Recent literature suggests that damage, loss of life, and costs from flooding have risen in recent decades (Ashley and Ashley 2008; Brissette et al. 2003). In a 2009 *Journal of Climate* article, Seager et al. noted that regions of the southeastern United States face increasing vulnerability to hydroclimatic extremes because of population growth and increasing population density. In 2008, a majority of the population lived in urban areas, and by 2030 this number is expected to reach 81%. The unsustainable, modified water cycle will affect the ecosystem, infrastructure, and societal activities, thereby requiring revolutionary designs, management, and policies. Burian and Shepherd (2005) and Reynolds et al. (2008) represent a sample of recent literature that has reconsidered implications of precipitation on urban drainage and hydrological processes.

In September 2009, the metropolitan area of Atlanta and surrounding areas in northern Georgia experienced disastrous urban flooding that inundated major transportation arteries, closed several major school systems, submerged the popular Six Flags theme park, and contributed to at least 10 deaths as of October 2009 (Fig. 1). The United States Geological Survey (USGS) measured the largest flow ever recorded on Sweetwater Creek near Austell, which has a streamflow record dating back to August 1904. Parts of Cobb and Douglas Counties were inundated to levels exceeding the estimated 500-yr flood. The Yellow River stream gauges in Gwinnett, DeKalb, and Rockdale Counties measured flows that submerged the 100-yr floodplains but failed to reach the 200-yr flood level, which has a 0.5% chance of occurring in any given year (www.usgs.gov/newsroom/article.asp?ID=2316). The 100-yr flood level with a 1% chance of occurrence in any given year is one of the standards that the Federal Emergency Management Agency (FEMA) uses to set flood insurance rates and prevent flood plain development. The USGS recorded 100-yr flood levels on the Chattahoochee River at Vinings in Atlanta (Fig. 2), where stage heights

AFFILIATIONS: Shepherd, Mote, Dowd, and Roden—University of Georgia, Athens, Georgia; Knox—Office of the State Climatologist, Athens, Georgia; McCutcheon— U.S. Environmental Protection Agency, Athens, Georgia; Nelson—National Weather Service, Peachtree City, Georgia
CORRESPONDING AUTHOR: Dr. J. Marshall Shepherd, University of Georgia, Climatological Research Laboratory, Department of Geography, Athens, Georgia 30602
E-mail: marshgeo@uga.edu

DOI:10.1175/2010BAMS3003.1

FIG. 1. (top) Flooding on U.S. Interstate 285 loop around Atlanta and (bottom) Six Flags theme park.

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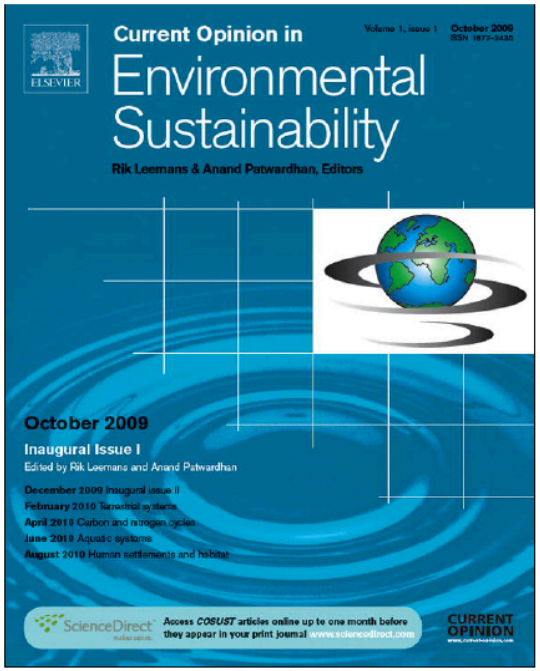
Current Opinion in Environmental Sustainability

Global urban land-use trends and climate impacts

Karen C Seto[1] and J Marshall Shepherd[2]



Current Opinion in Environmental Sustainability

Rik Leemans & Anand Patwardhan, Editors

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CURRENT OPINION