New Dimensions in Monitoring Patterns of Urban Change

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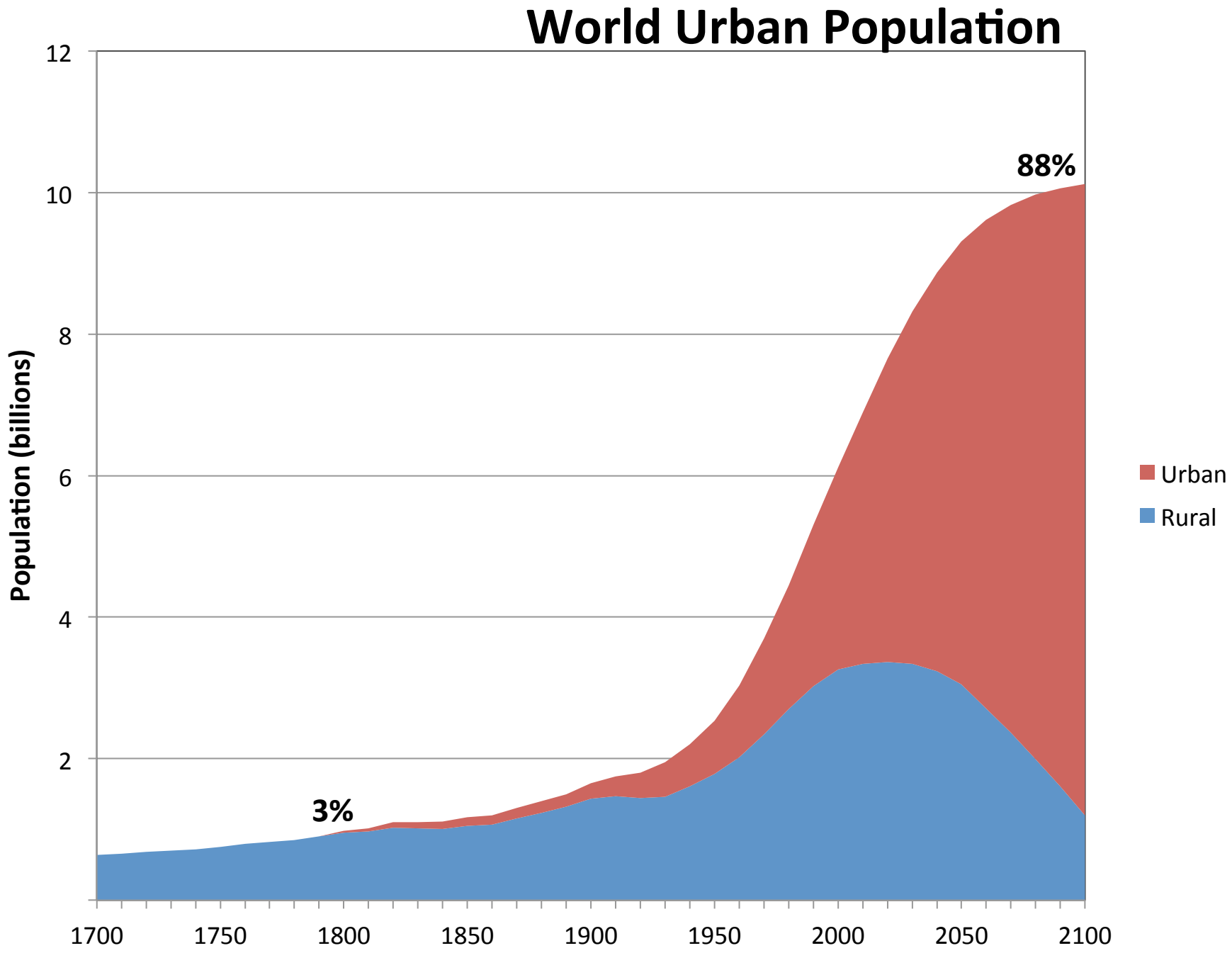
Secondary Cities Symposium:
June 15, 2016

NASA Goddard SPACE FLIGHT CENTER

Yale University
School of Forestry
& Environmental Studies

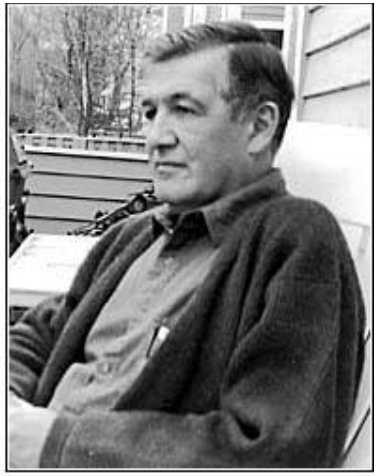


(UN. 2011. *World Urbanization Prospects*)

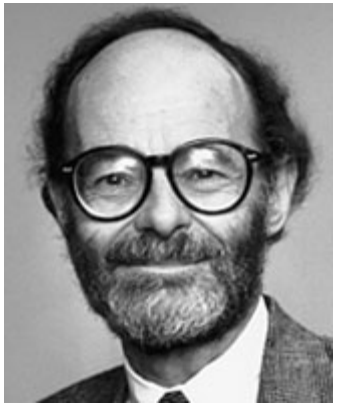
von Thünen

Burgess

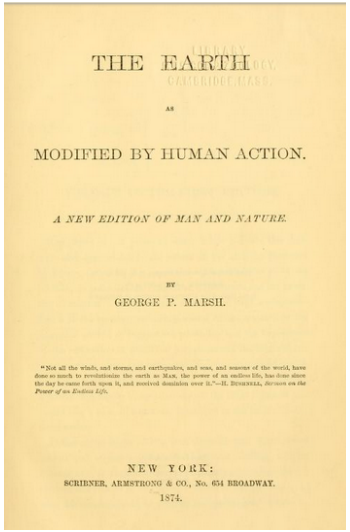
Alonso



Mills



Isard



THE EARTH

AS

MODIFIED BY HUMAN ACTION.

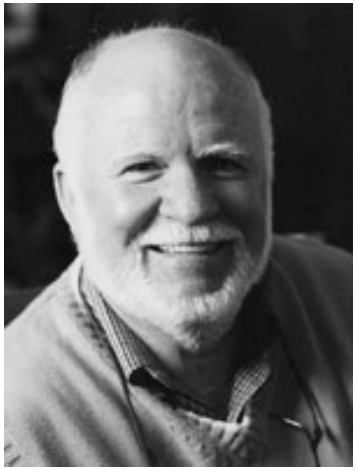
A NEW EDITION OF MAN AND NATURE.

BY

GEORGE P. MARSH.

"Not all the winds, and storms, and earthquakes, and seas, and seasons of the world, have done so much to revolutionize the earth as Man, the power of an endless life, has done since the day he came forth upon it, and received dominion over it."—H. Bushnell, *Sermon on the Power of an Endless Life.*

NEW YORK:
SCRIBNER, ARMSTRONG & CO., No. 654 BROADWAY.
1874.



Marsh

Boserup

Turner

Irwin

What drives urban land use
& urban land use change?

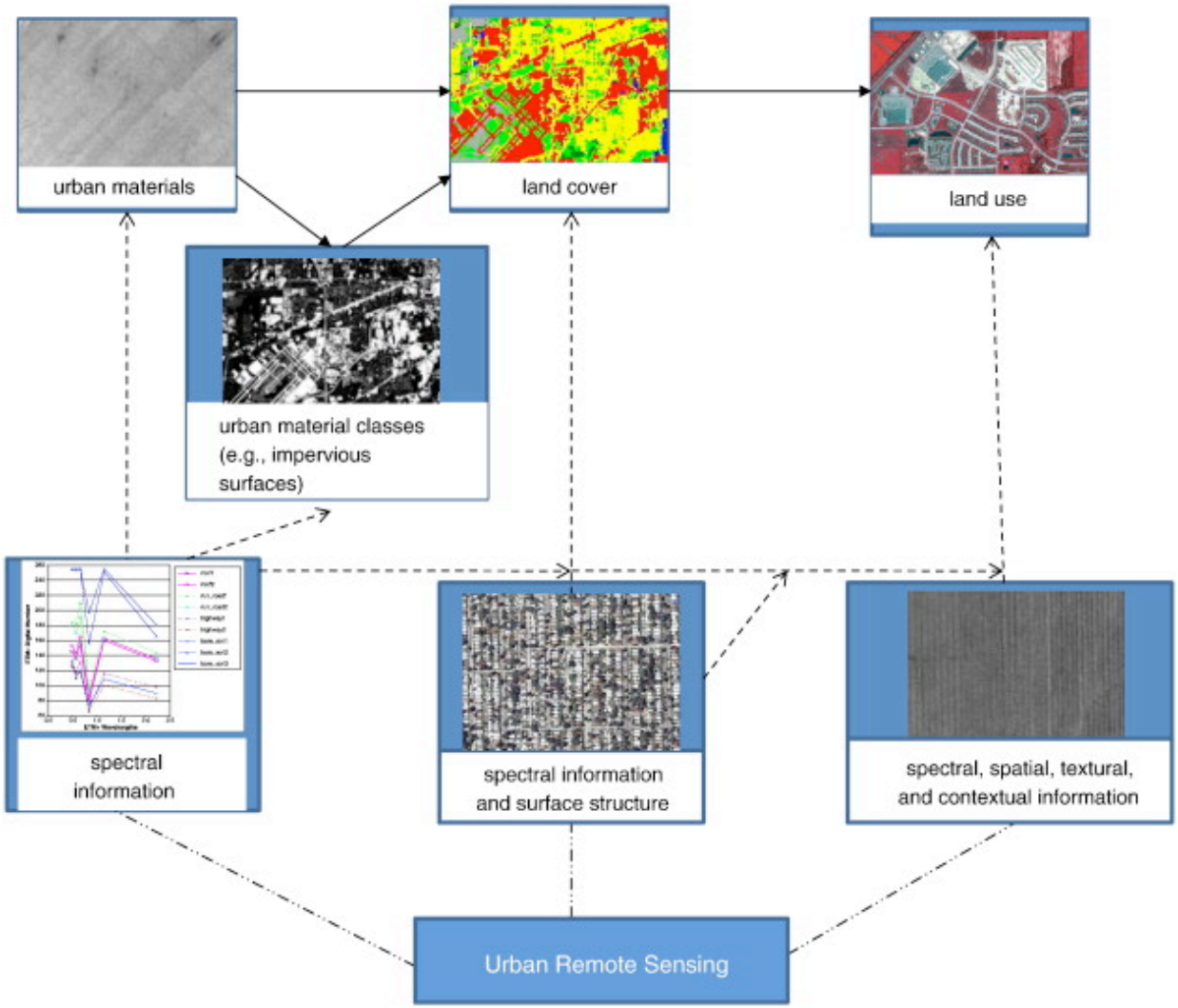
What are the environmental effects of
urban land use & urban land use change?

MAPS

Urban land cover/use classes

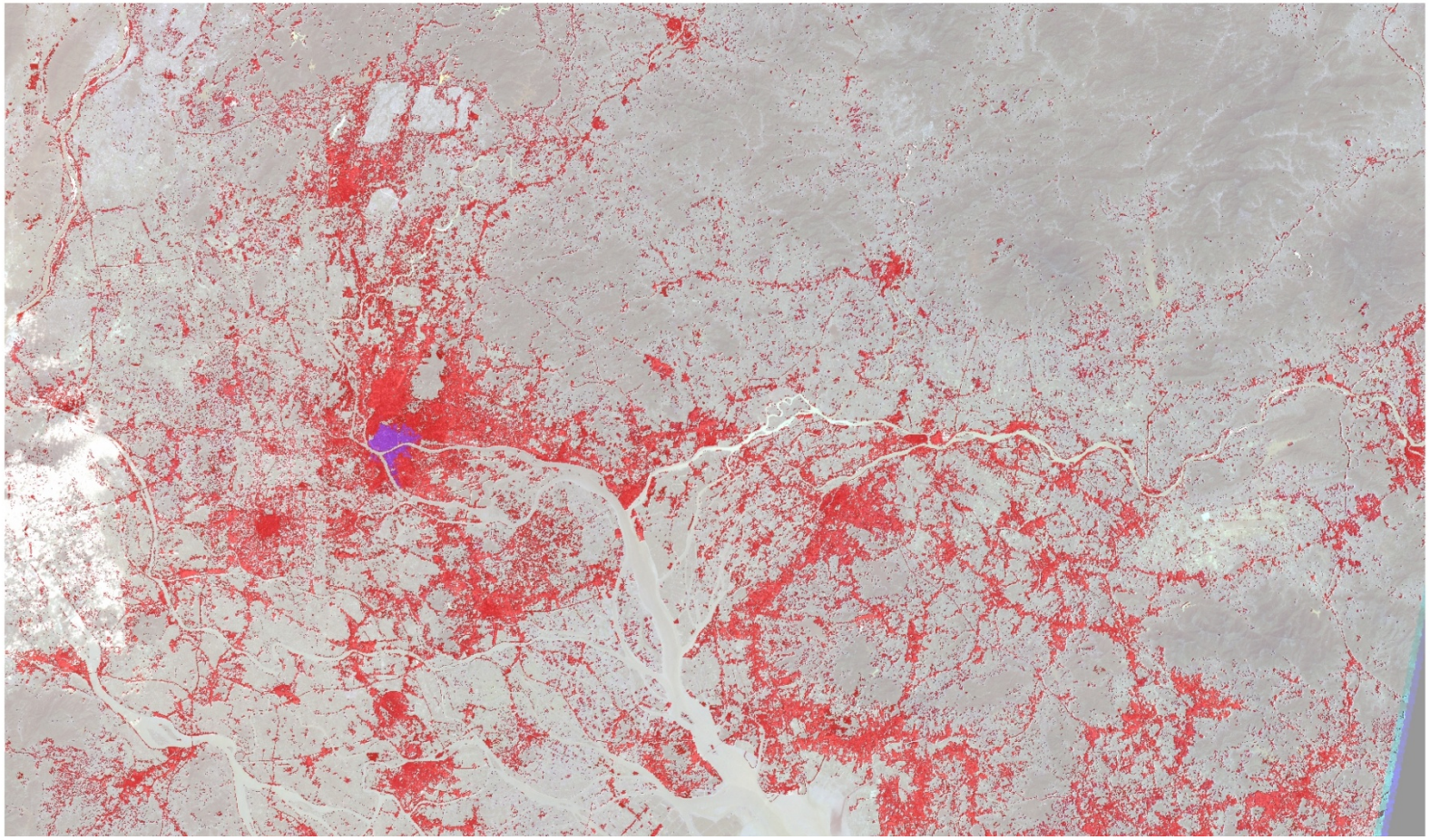
Aerial photography, IKONOS, LANDSAT, SPOT, SAR

(Benediktsson et al, 2005; Plamason et al., 2005; van der Linden et al., 2007; Herold et al., 2004; Heiden et al., 2007; Roessner et al., 2001; Barr and Barnsley, 1997; Mesev, 2010; Hasse and Lathrop, 2003)



(Weng, 2012)

Urban Growth in Pearl River Delta, China - 1999



Urban Extent

IKONOS, LANDSAT, SPOT, SAR, DMSP-OLS

(Bowden and Brooner, 1970; Schneider et al., 2009; Potere et al., 2009; Burchfield et al., 2006; Mallick and Rahman, 2012; Grey and Luckman, 2003; Imhoff et al., 1997; Gober and Burns, 2002; Sutton et al., 2006; Elvidge et al., 2004; Li et al., 2013)

0 10 20 40 Kilometers

Novel ways we use remote sensing to monitor urban change?

1. NOAA SeaWinds
2. Multi-date VIIRS NTL data

OPEN ACCESS
IOP PUBLISHING
ENVIRONMENTAL RESEARCH LETTERS
Environ. Res. Lett. 8 (2013) 024004 (10pp)
doi:10.1088/1748-9326/8/2/024004

A global fingerprint of macro-scale changes in urban structure from 1999 to 2009

Steve Frolking[1,2,5], Tom Milliman[1], Karen C Seto[3] and Mark A Friedl[4]

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[2] Department of Earth Sciences, University of New Hampshire, Durham, NH 03824, USA
[3] School of Forestry and Environmental Studies, Yale University, New Haven, CT 06511, USA
[4] Department of Earth and Environment, Boston University, Boston, MA 02215, USA

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How do scatterometers work?

- Designed to measure winds over ocean
- Can also be used for land and ice studies
- Active remote sensing: transmits pulses of microwave energy and measures the returned echo.
- Energy in returned echo depends on **electrical** properties and **roughness** of the surface.
- Over land: return echo is function of land cover.

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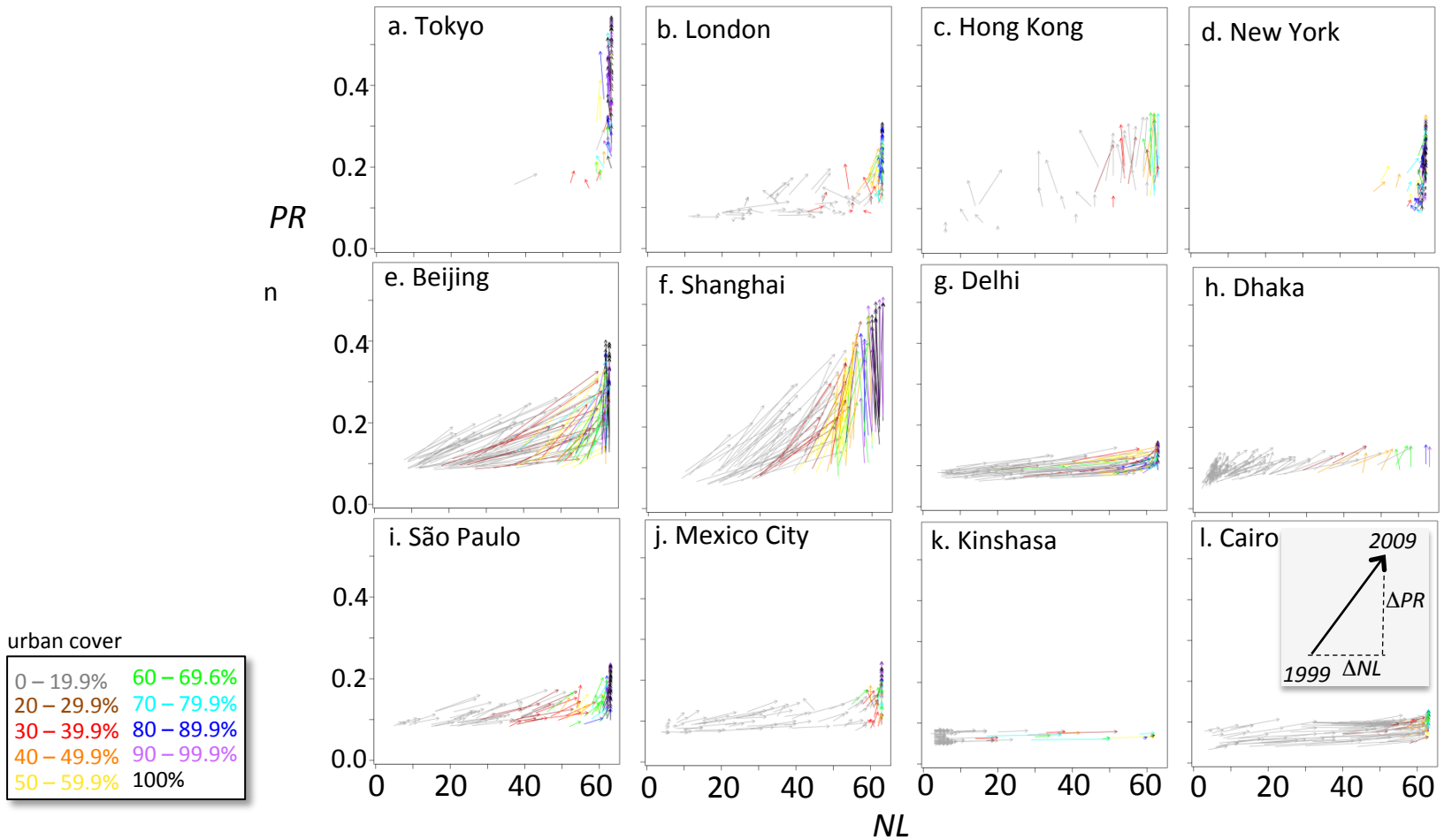

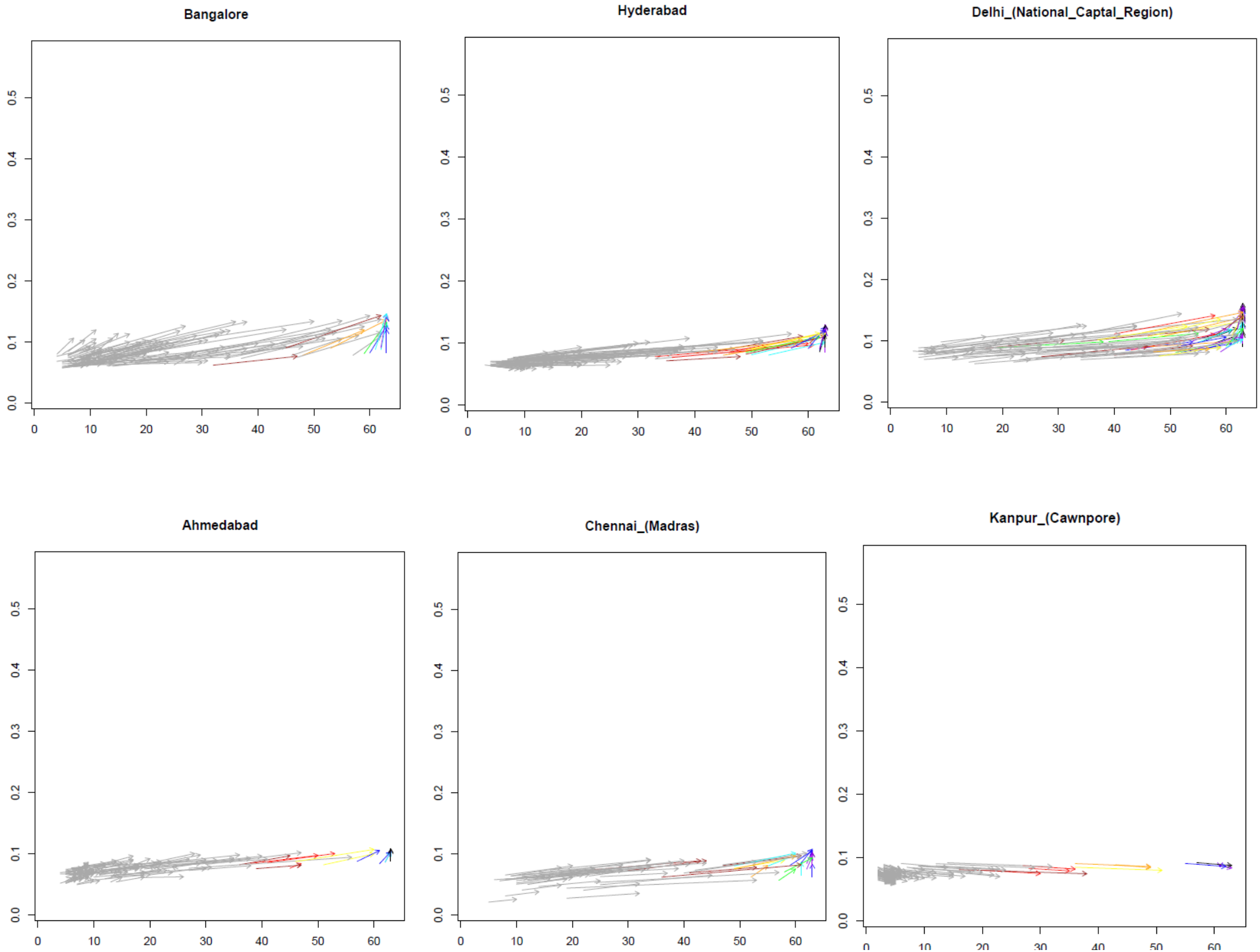
Bangalore
Hyderabad
Delhi_(National_Captal_Region)
Ahmedabad
Chennai_(Madras)
Kanpur_(Cawnpore)
0.0
0.1
0.2
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0.4
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0
10
20
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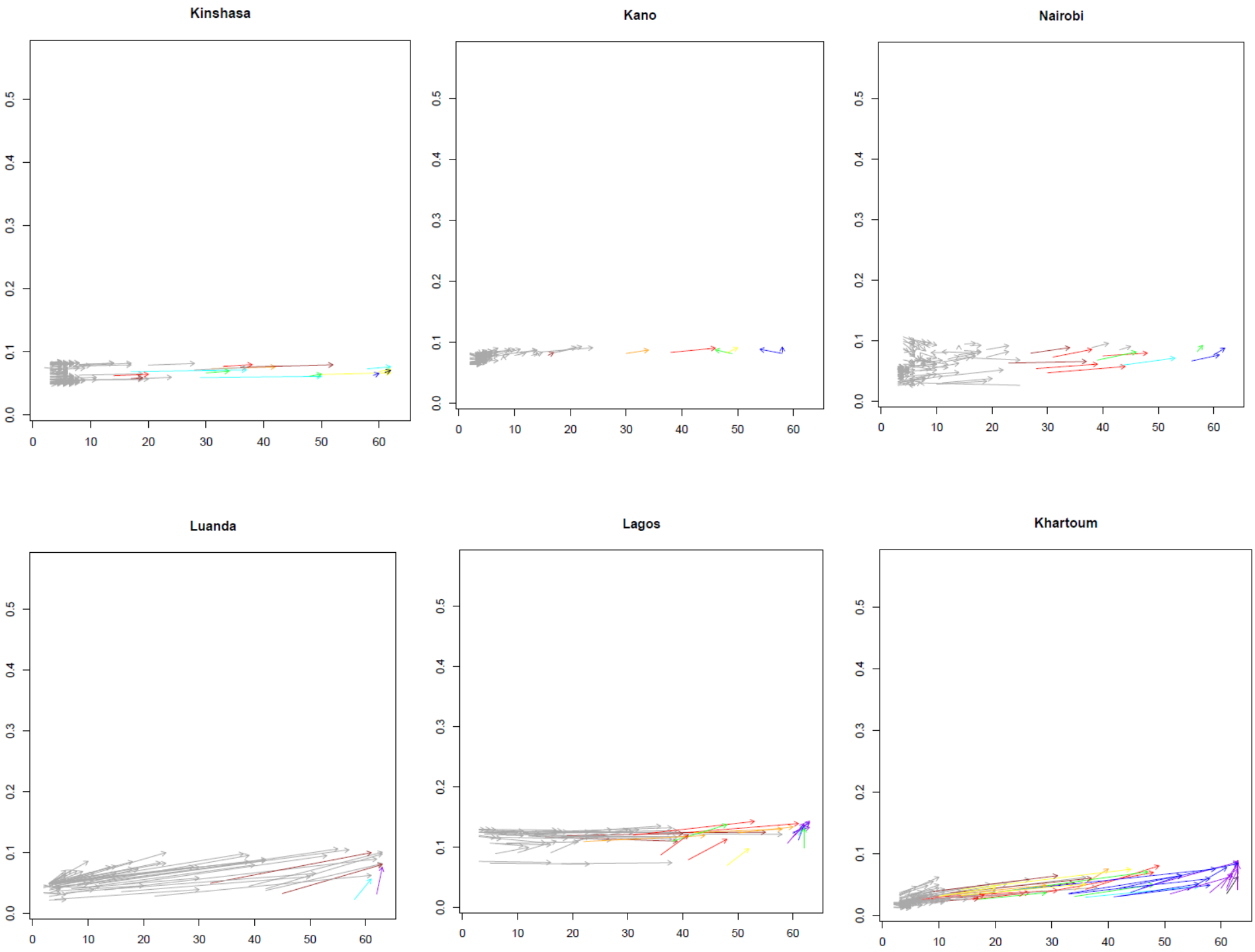
40
50
60


Kinshasa
Kano
Nairobi
Luanda
Lagos
Khartoum
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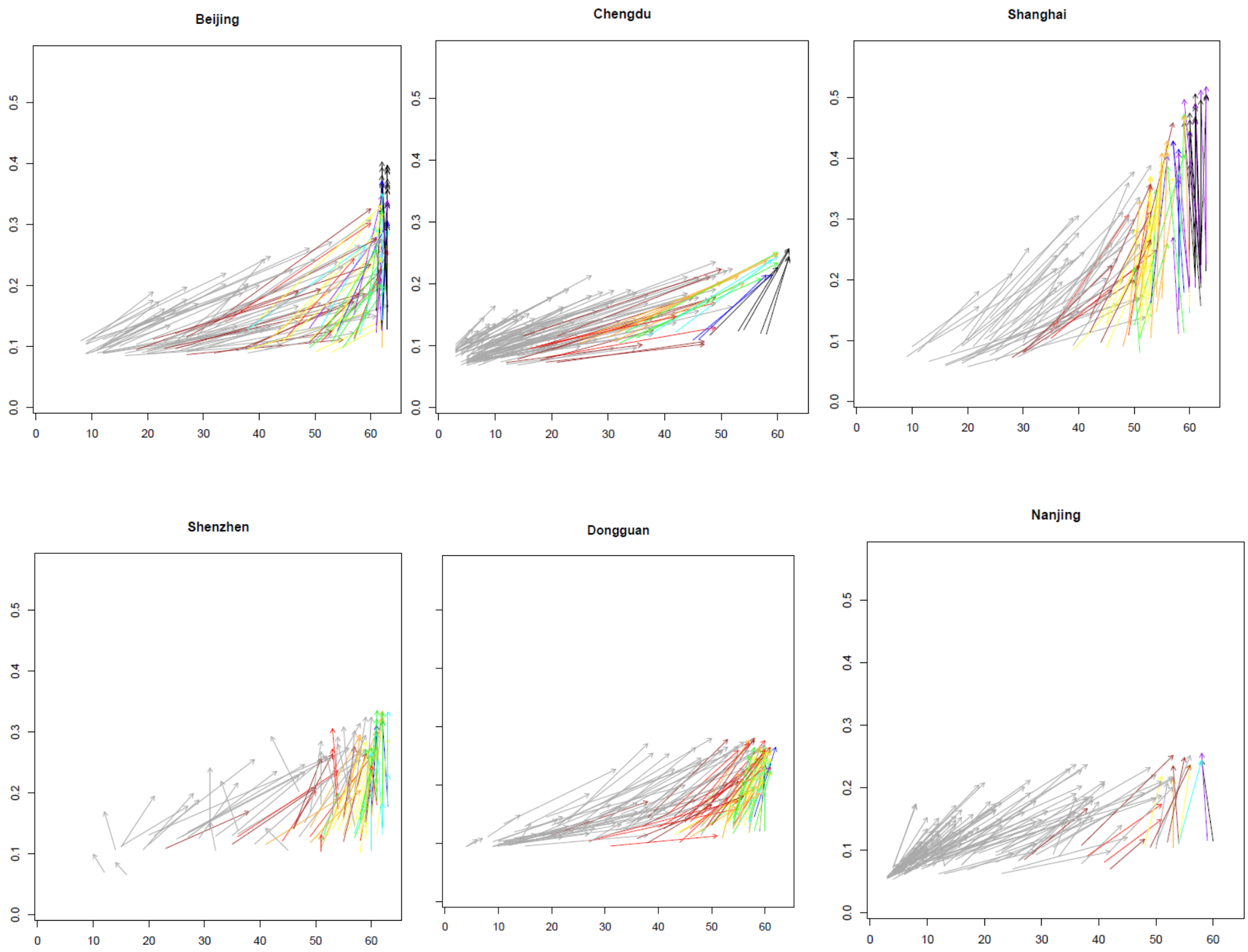
Beijing
Chengdu
Shanghai
Shenzhen
Dongguan
Nanjing
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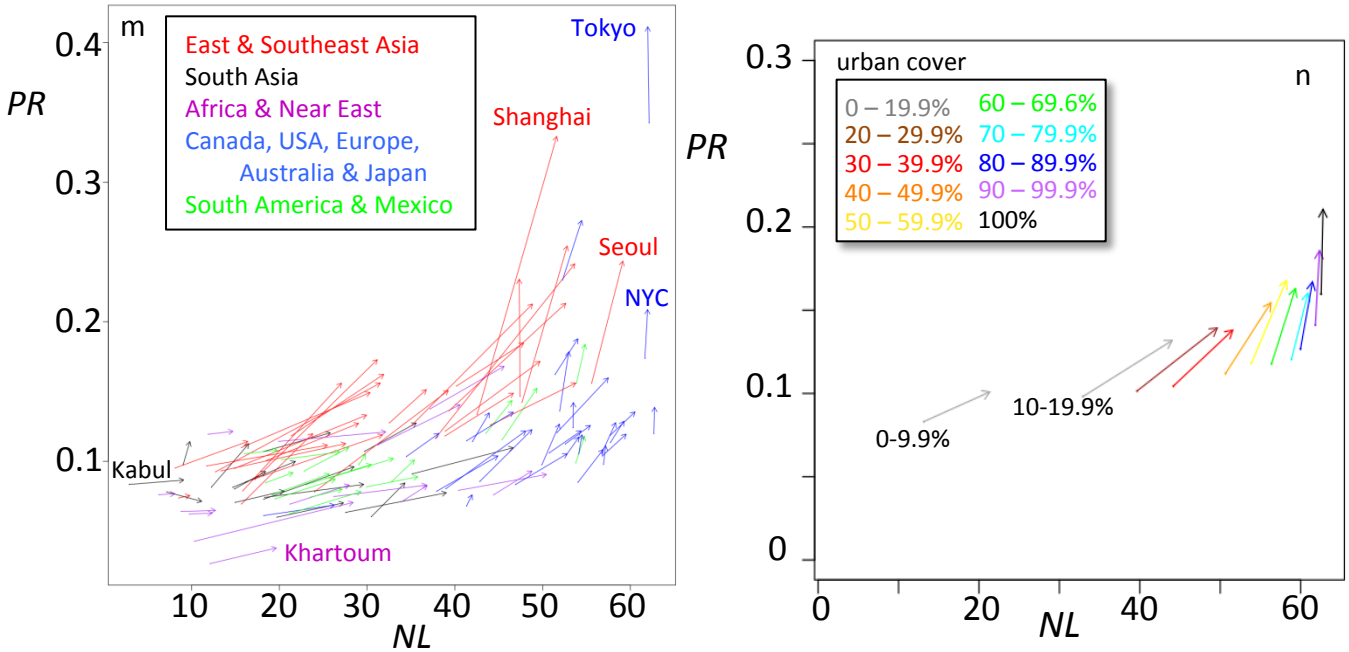
m
East & Southeast Asia
South Asia
Africa & Near East
Canada, USA, Europe,
Australia & Japan
South America & Mexico
Tokyo
Shanghai
Seoul
NYC
Kabul
Khartoum
PR
NL
0.4
0.3
0.2
0.1
10
20
30
40
50
60
urban cover
n
0 – 19.9%
20 – 29.9%
30 – 39.9%
40 – 49.9%
50 – 59.9%
60 – 69.6%
70 – 79.9%
80 – 89.9%
90 – 99.9%
100%
0-9.9%
10-19.9%
0.3
0.2
0.1
0
0
20
40
60

Novel ways we use remote sensing to monitor urban change?

1. NOAA SeaWinds
2. Multi-date VIIRS NTL data

AGU PUBLICATIONS

Earth's Future

RESEARCH ARTICLE

10.1002/2014EF000285

Key Points:

- Science-quality VIIRS night-sky products can capture short-term changes in energy service demand
- We explore the influence of cultural, socioeconomic, and geopolitical groupings on energy use patterns
- We conclude that energy decision-making and demand is both an individual and sociocultural process

Corresponding Authors:

Holidays in lights: Tracking cultural patterns in demand for energy services

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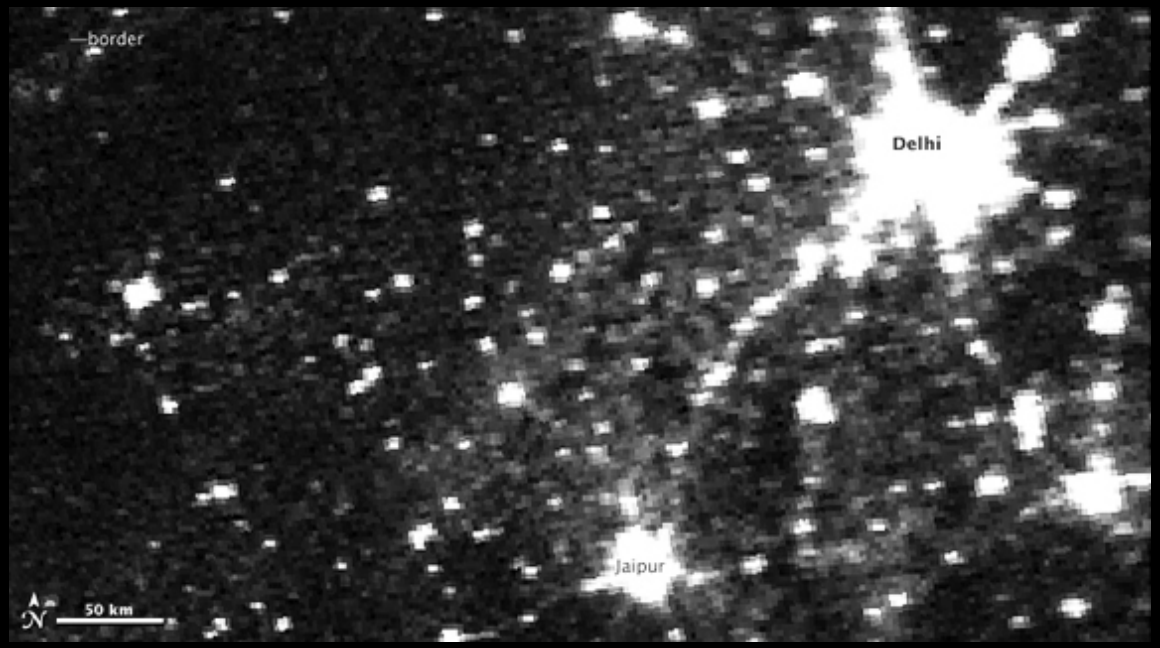
[1]NASA Goddard Space Flight Center, Terrestrial Information Systems Laboratory, Greenbelt, Maryland, USA, [2]School of Forestry and Environmental Studies, Yale University, New Haven, Connecticut, USA

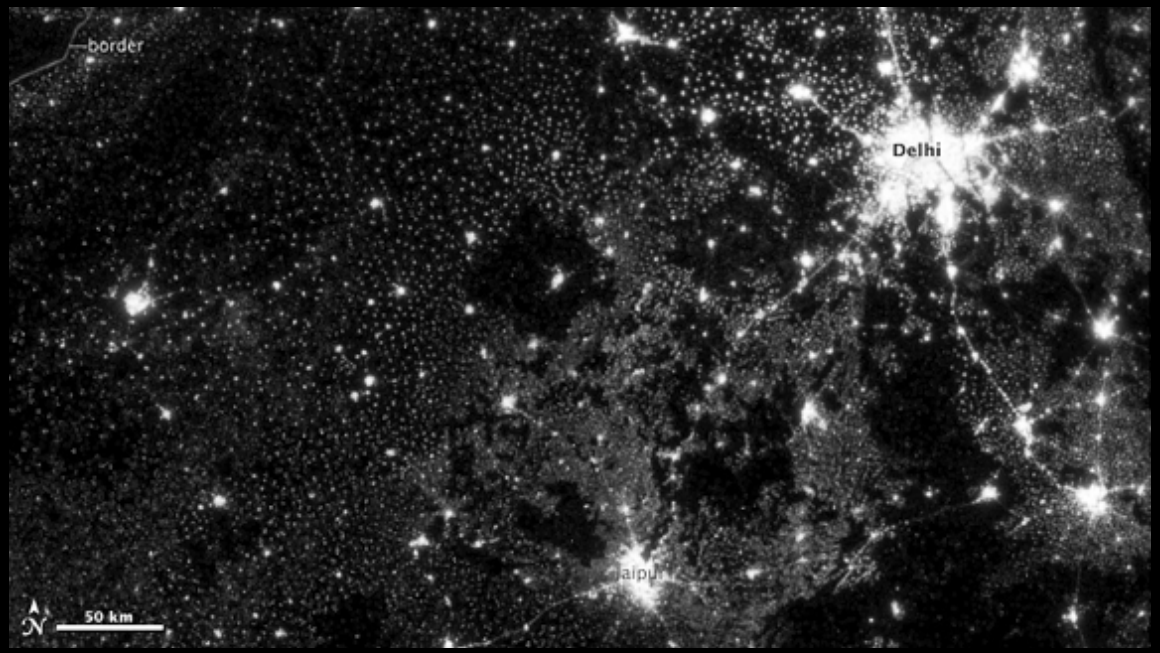
[†]The authors contributed equally to this work.

Abstract Successful climate change mitigation will involve not only technological innovation, but also innovation in how we understand the societal and individual behaviors that shape the demand for energy services. Traditionally, individual energy behaviors have been described as a function of utility optimiza-tion and behavioral economics, with price restructuring as the dominant policy lever. Previous research at the macro-level has identified economic activity, power generation and technology, and economic role as



DMSP-OLS

- Data since 1972, digital data since 1992

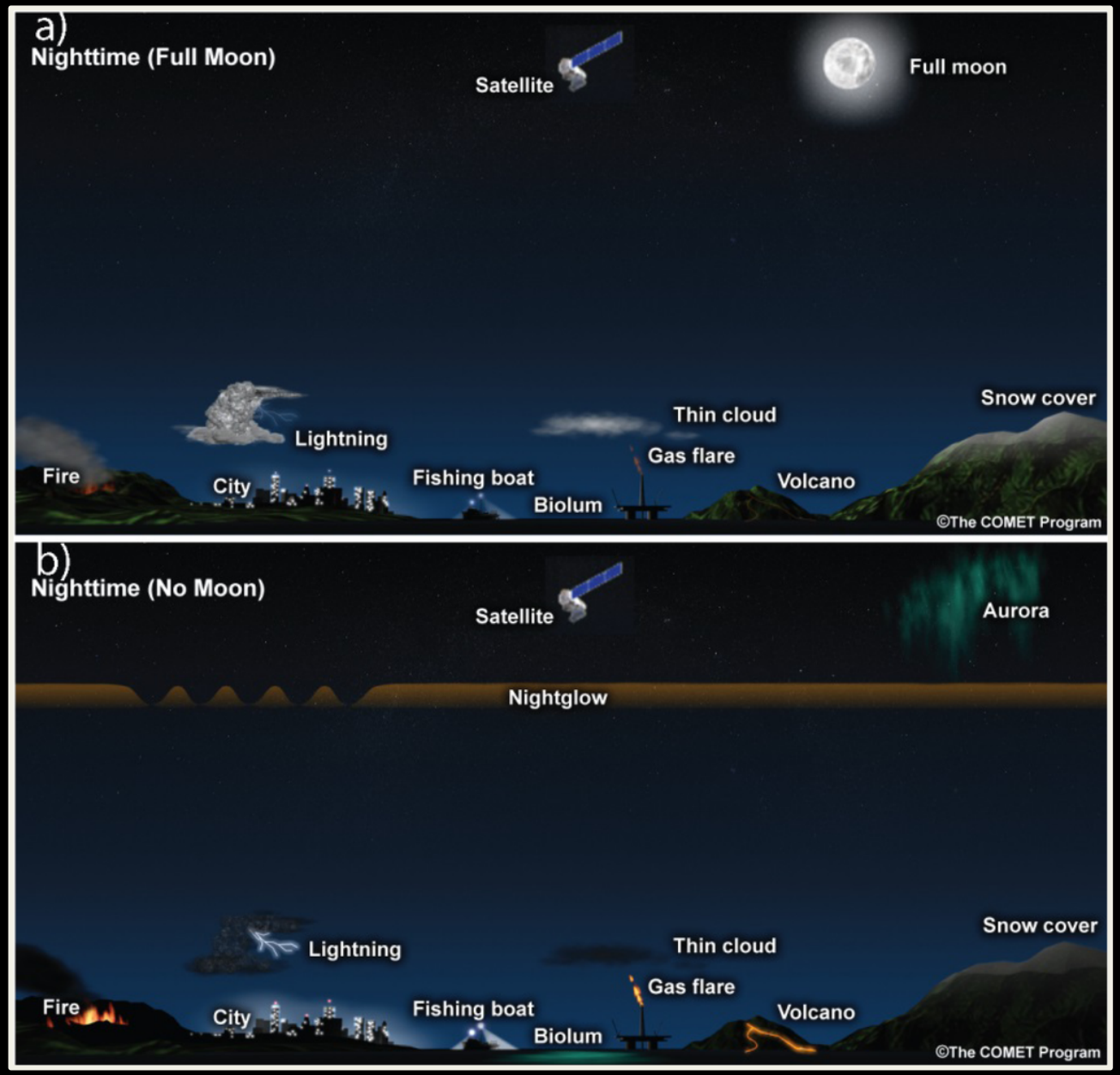


VIIRS

- Data since Jan. 19, 2012
- Higher spatial resolution
- Higher radiometric resolution

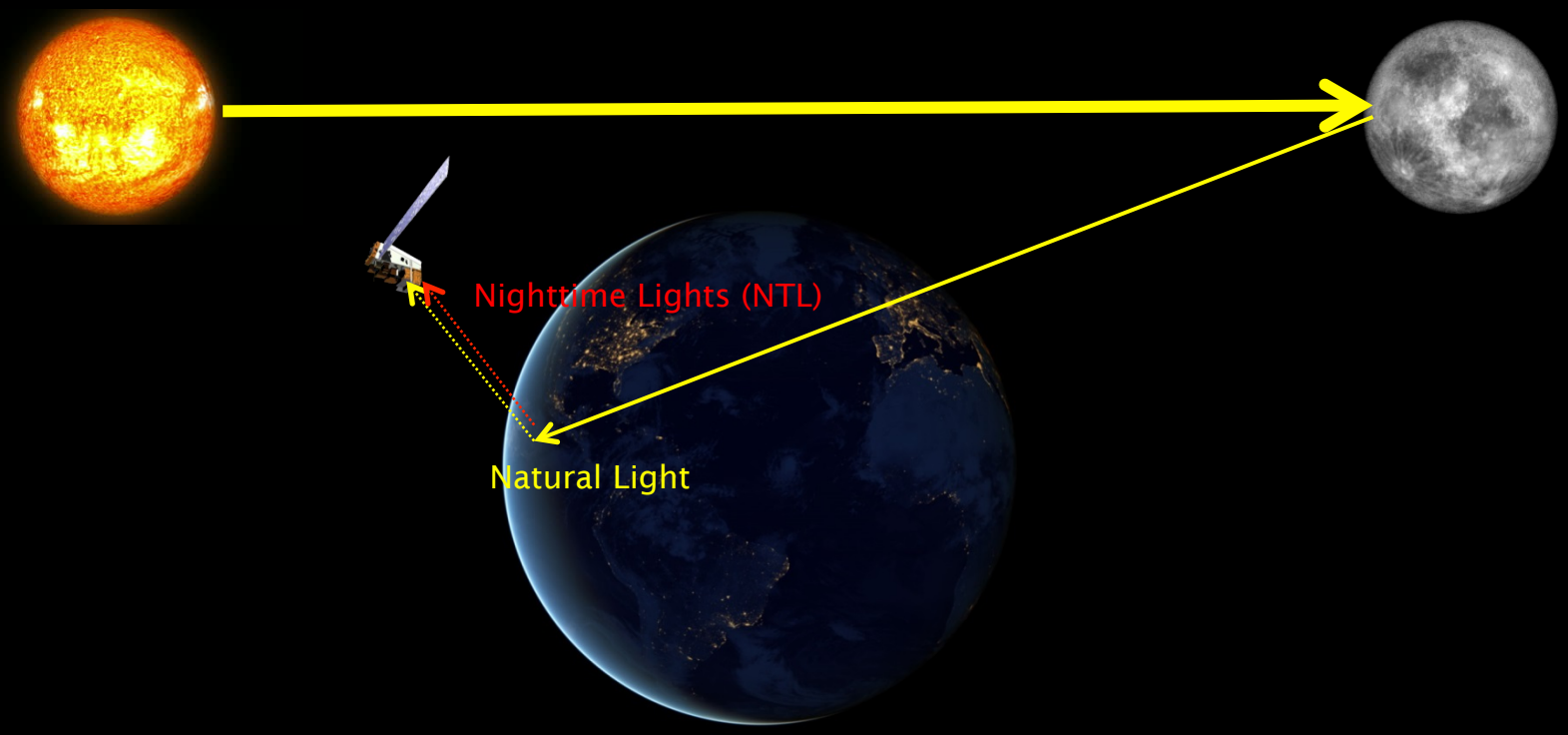
VIIRS (top) and DMSP-OLS (bottom) NTL images of Delhi

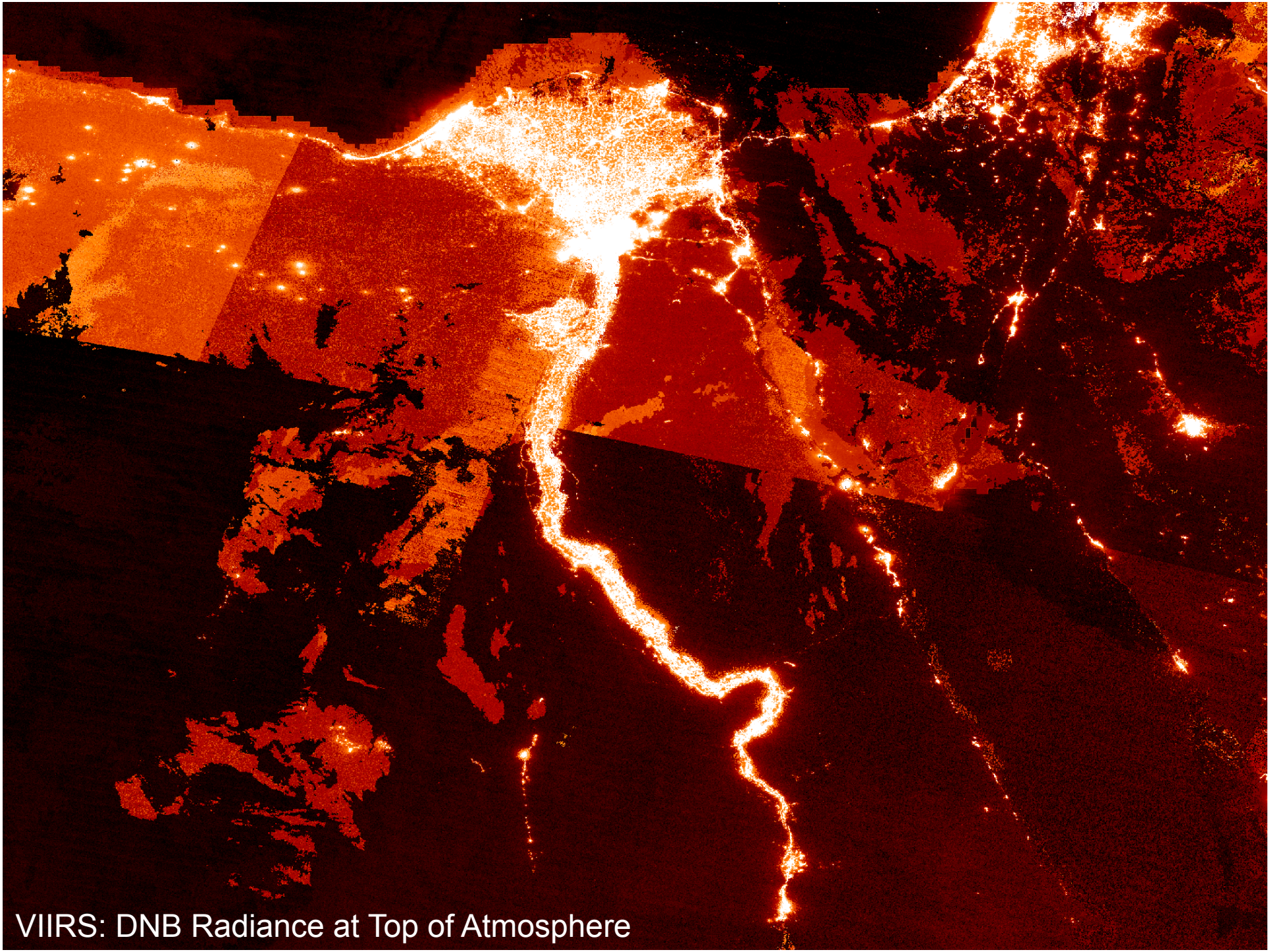
VIIRS nighttime detection capabilities (a) with and (b) without lunar illumination

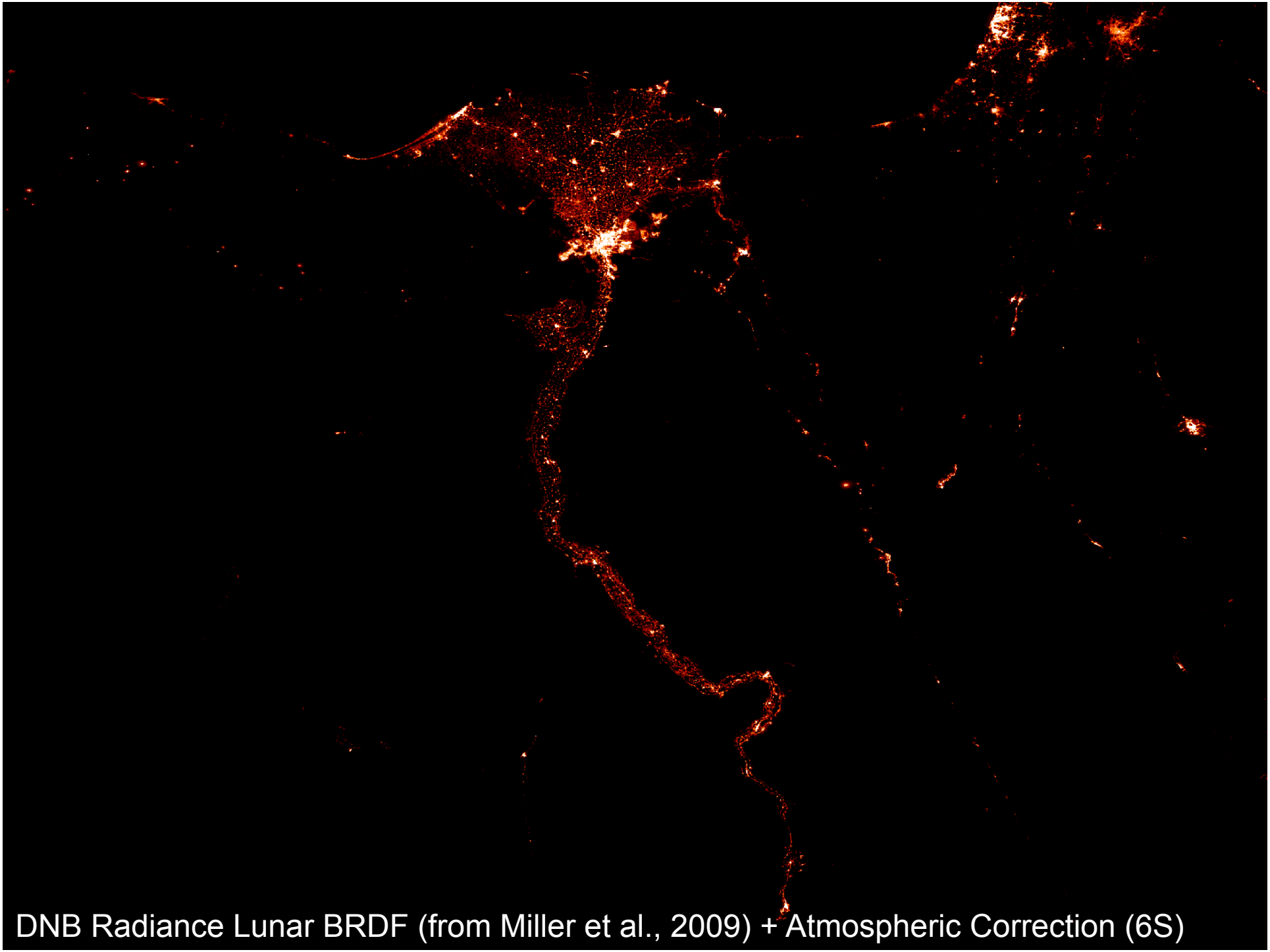


Miller et al., (2013) *Remote Sens. 2013, 5(12), 6717-6766; doi:10.3390/rs5126717*

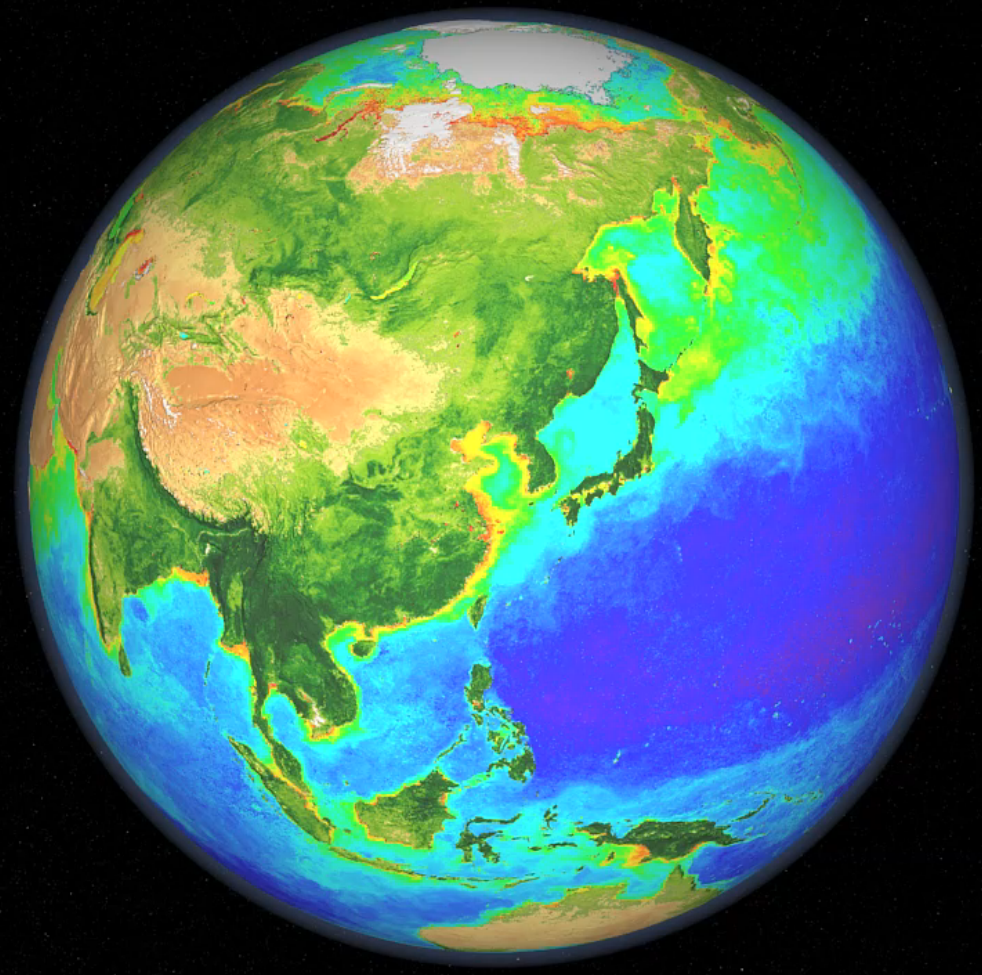
Principles of Nighttime Remote Sensing

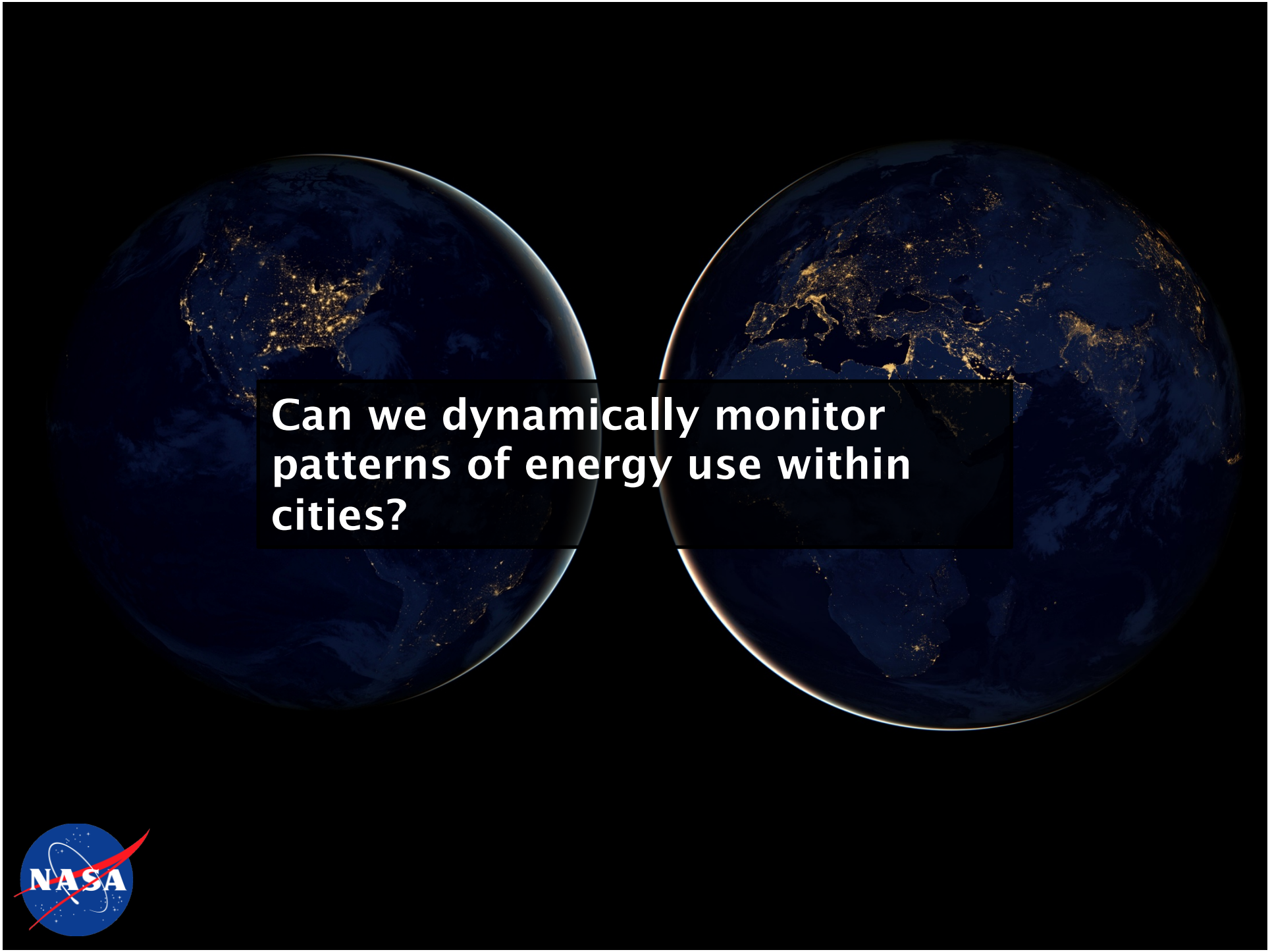



VIIRS: DNB Radiance at Top of Atmosphere


DNB Radiance Lunar BRDF (from Miller et al., 2009) + Atmospheric Correction (6S)

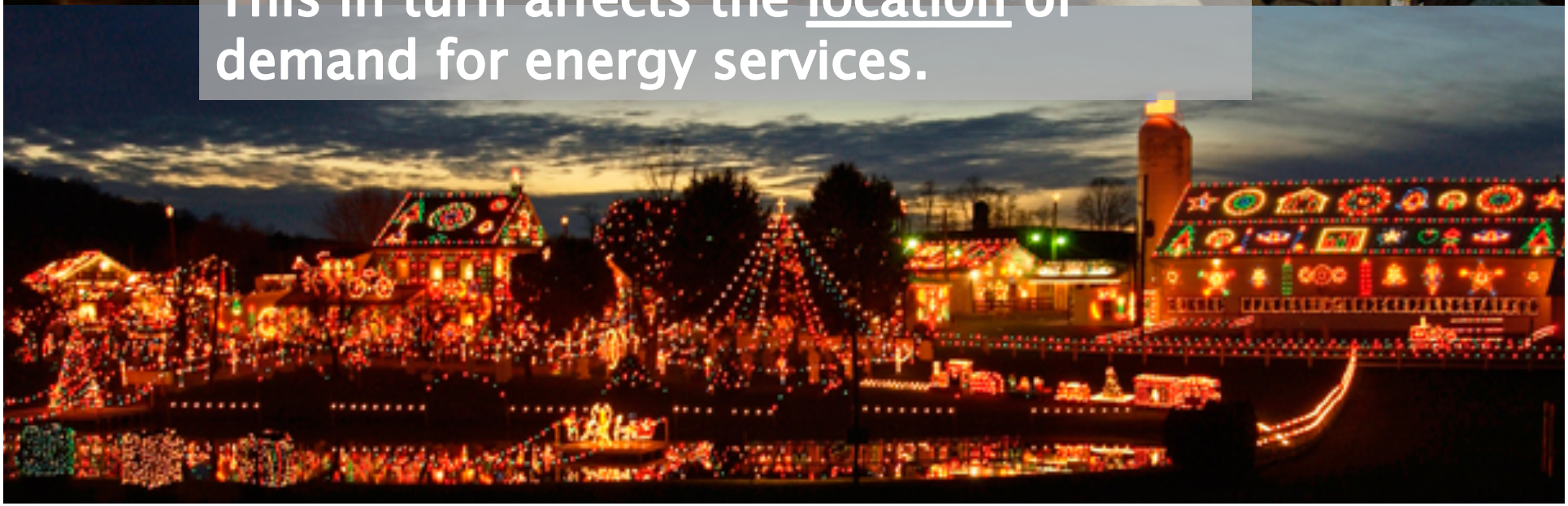
SeaWiFS Dynamic Biosphere (2001–2006)

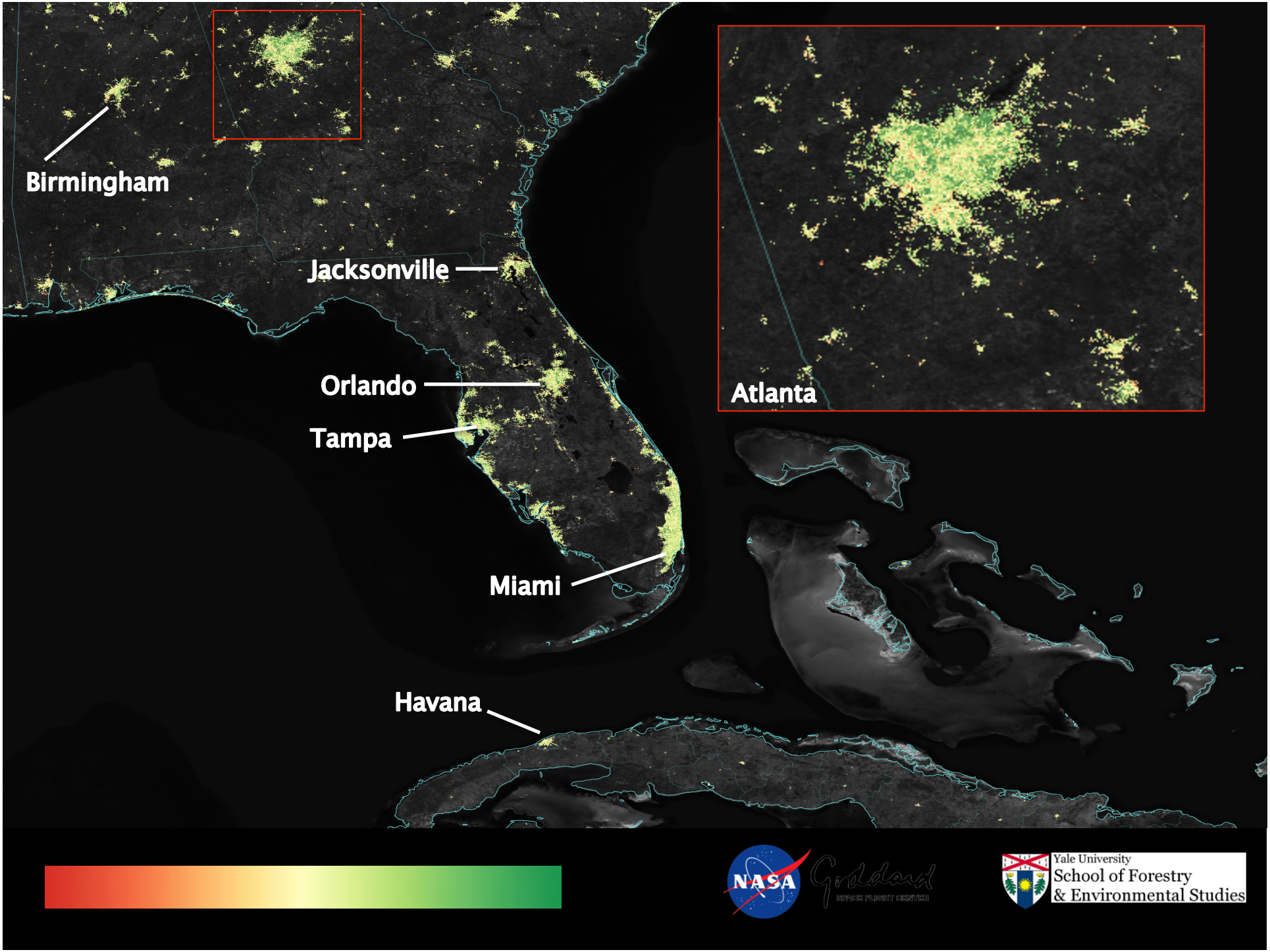


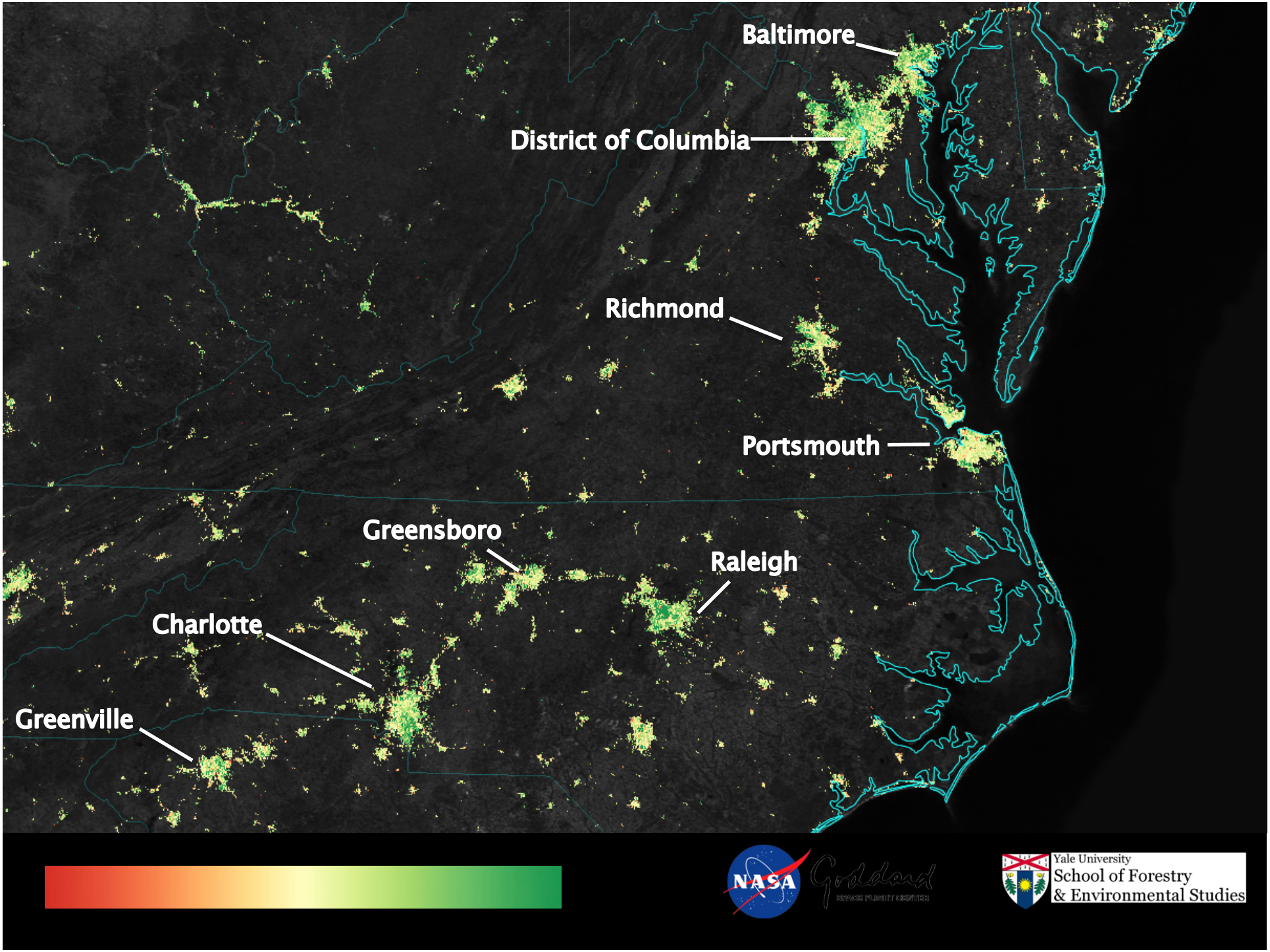


Can we dynamically monitor patterns of energy use within cities?

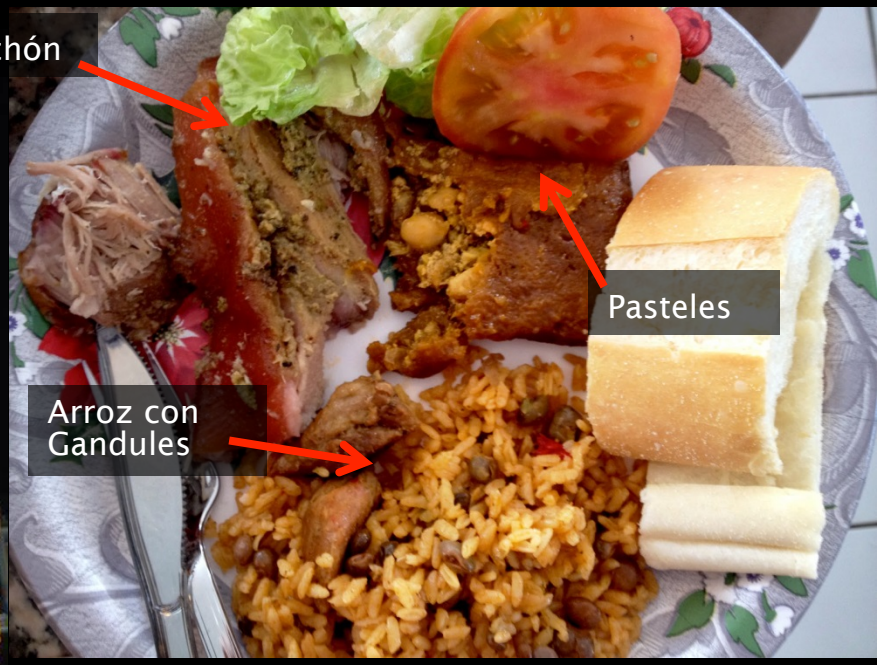
What's happening during the Holidays?
Human activity patterns are changing.
This in turn affects the <u>location</u> of demand for energy services.



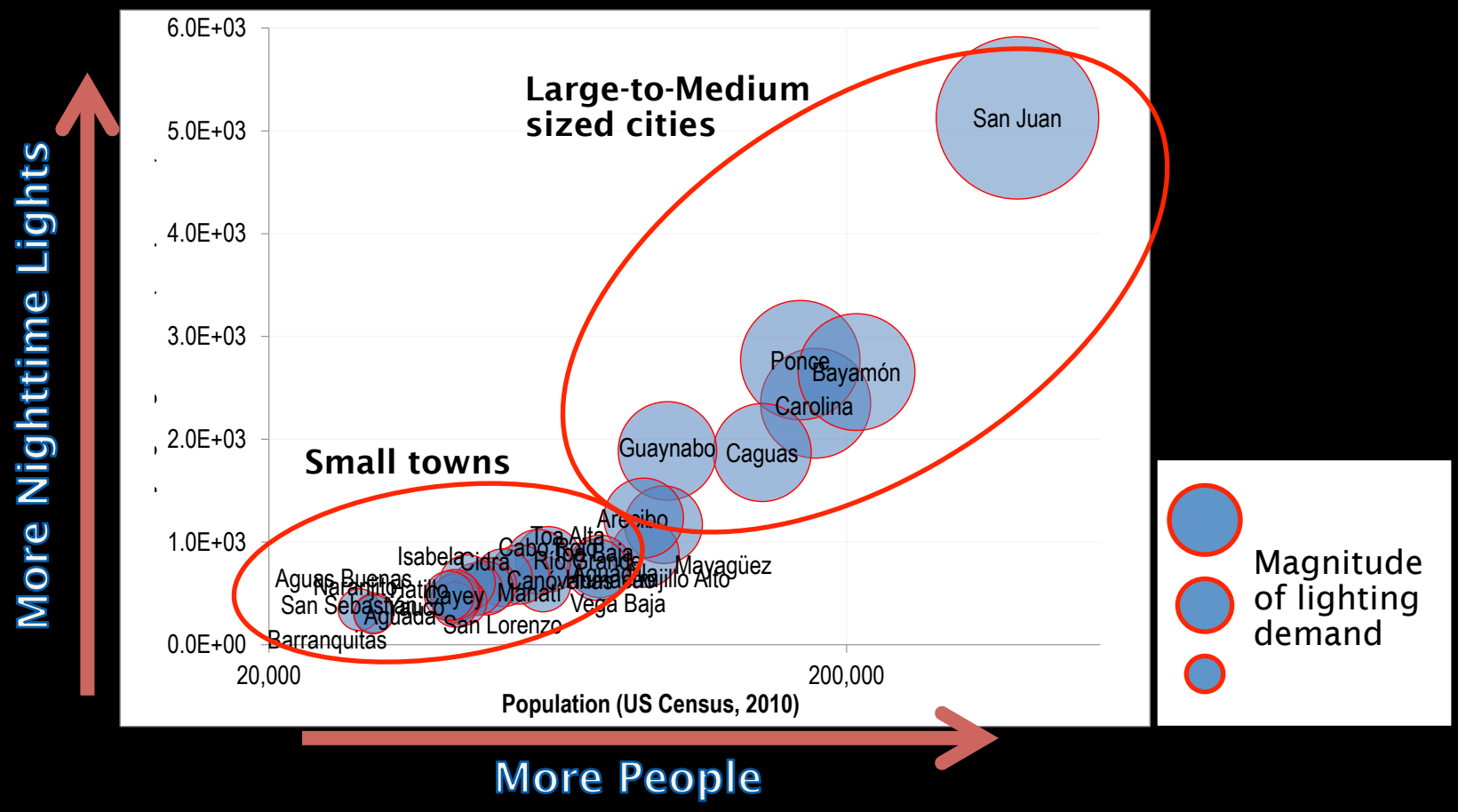

Birmingham
Jacksonville
Orlando
Tampa
Miami
Havana
Atlanta
NASA
Goddard
SPACE FLIGHT CENTER
Yale University
School of Forestry
& Environmental Studies


Baltimore
District of Columbia
Richmond
Portsmouth
Greensboro
Raleigh
Charlotte
Greenville
NASA
Goddard
SPACE FLIGHT CENTER
Yale University
School of Forestry
& Environmental Studies

Holiday Season in Puerto Rico

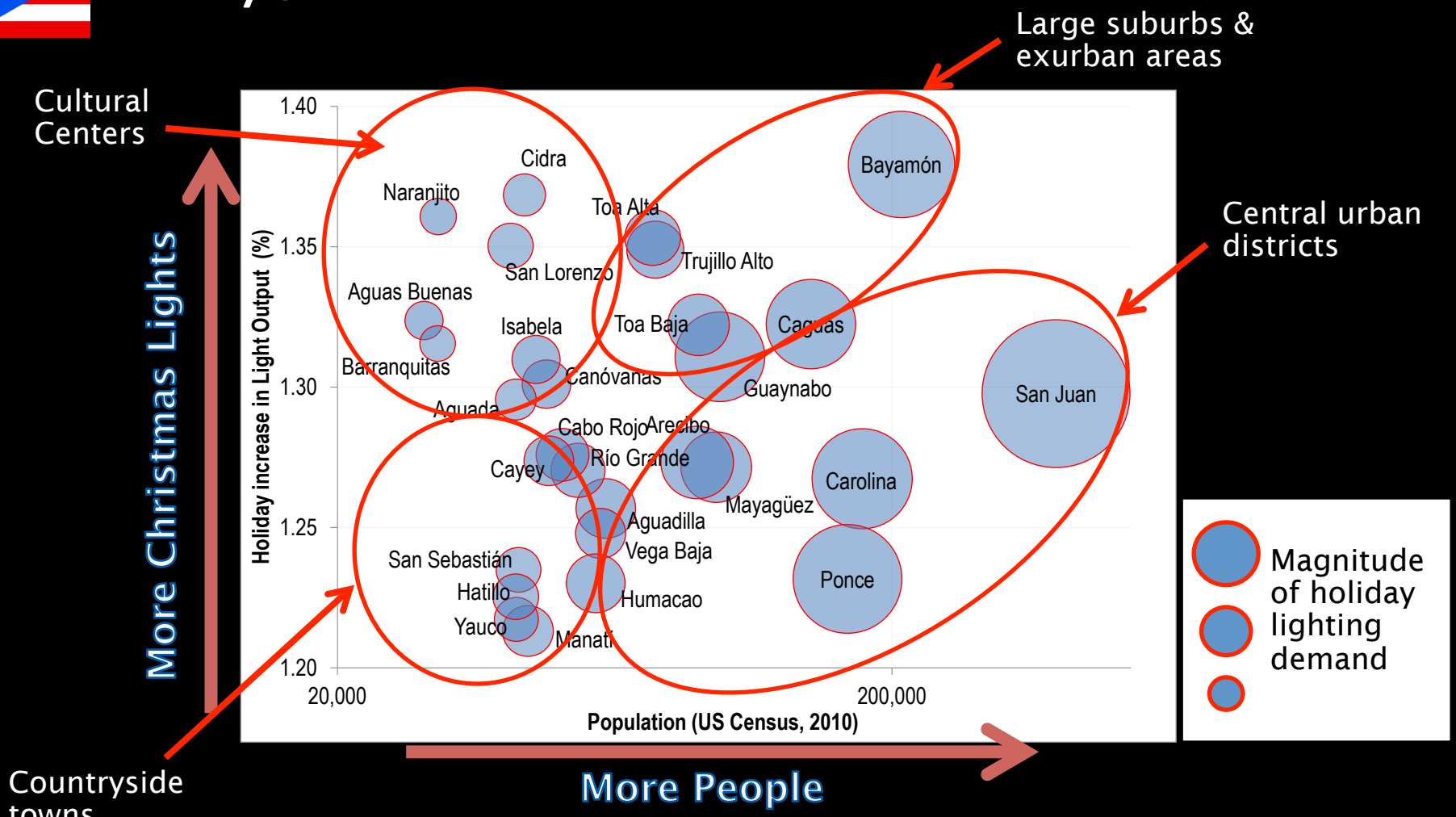


Holiday Season in Puerto Rico



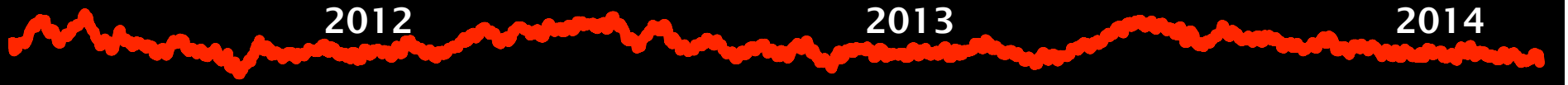
In the past, cities have been described from the impervious footprint and built infrastructure within urban boundaries.

Holiday Season in Puerto Rico



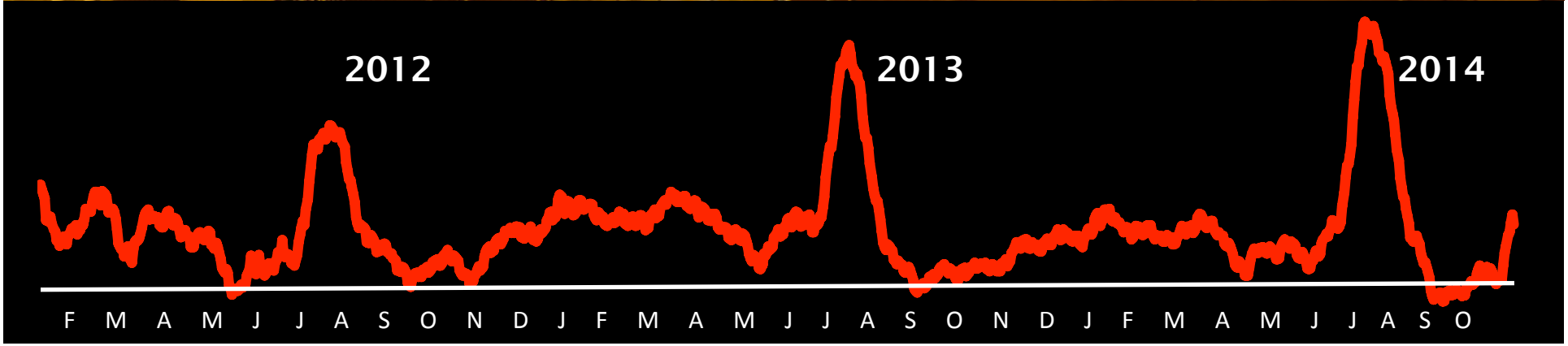
Dynamic nighttime monitoring enables new descriptions of families of cities, not just solely based on their physical size, but also based on the energy behaviors of a city's inhabitants.

Tel Aviv, Israel

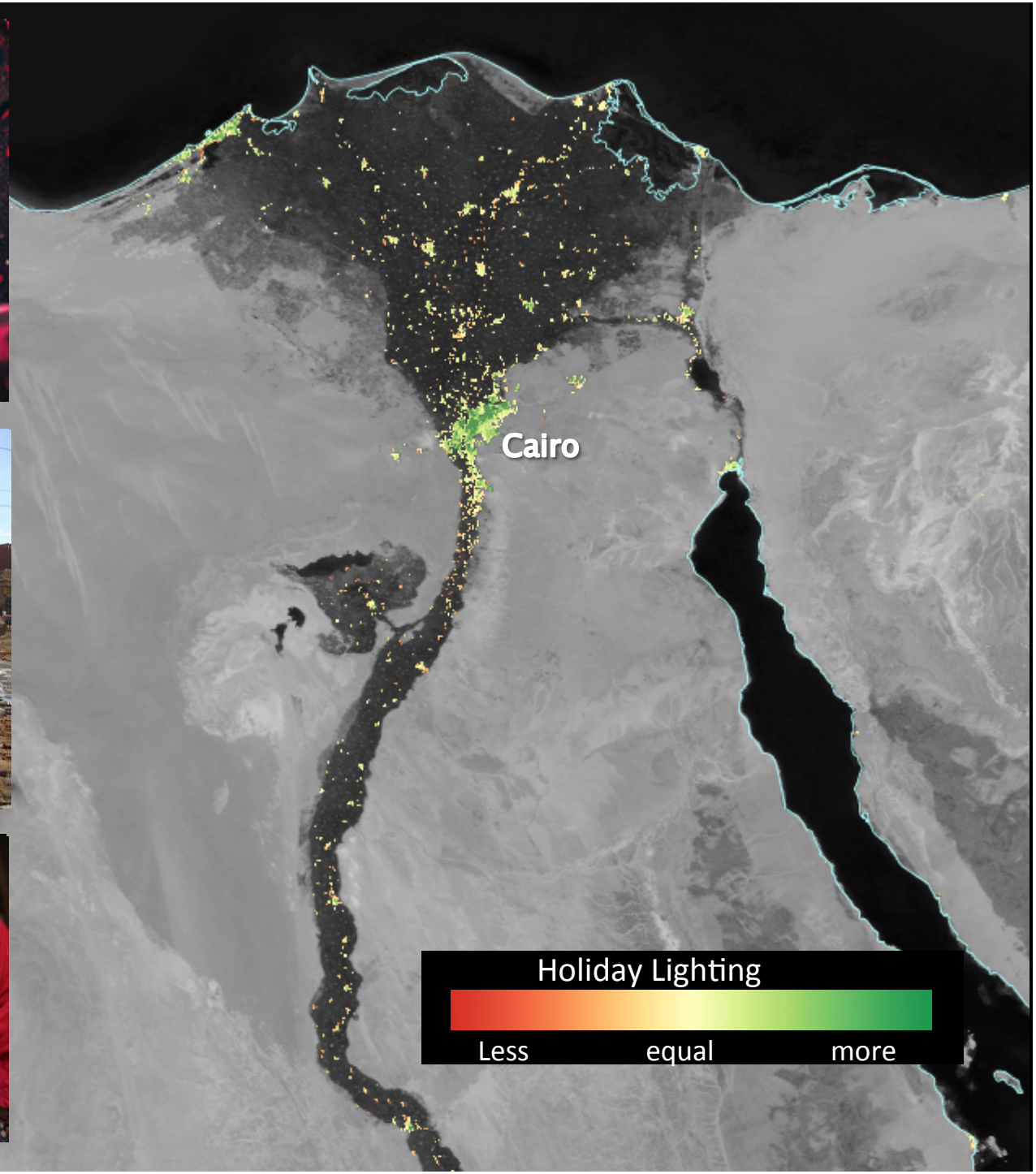


F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O

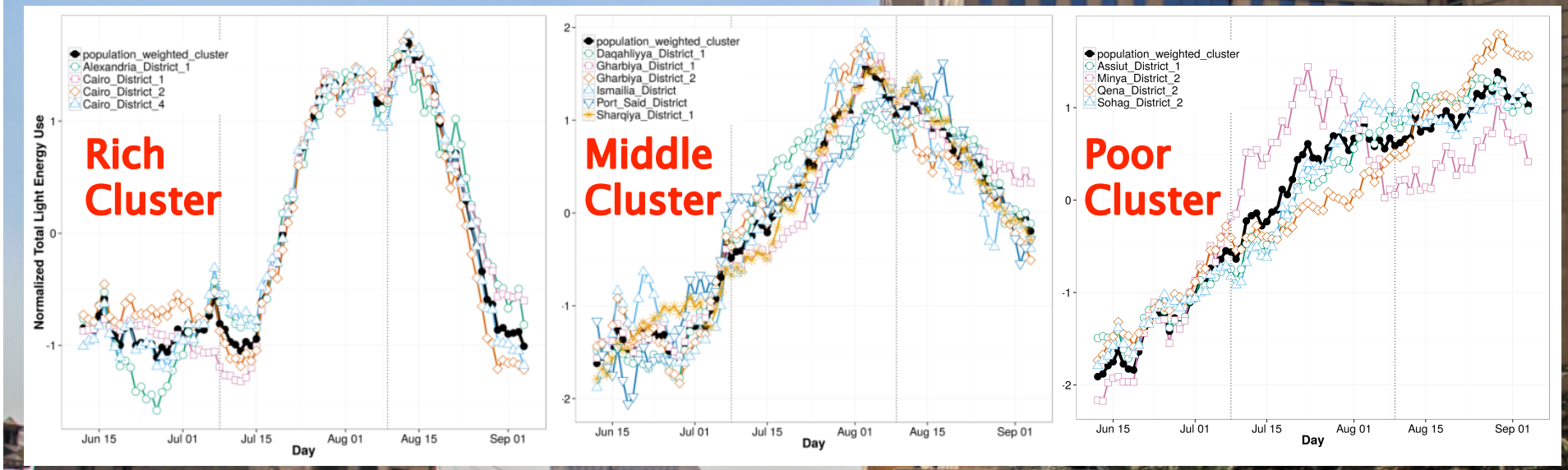
Jeddah, Saudi Arabia

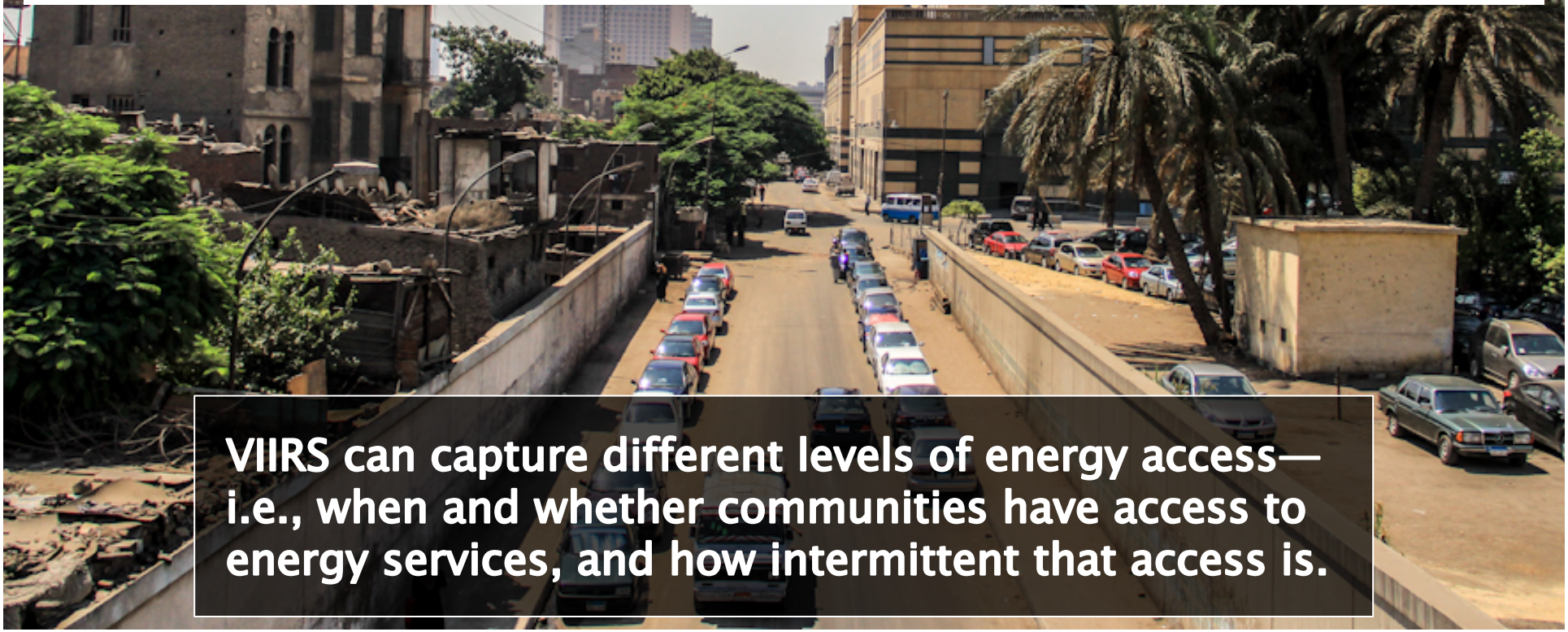


Human Activity: Ramadan, 2012 (Jul19 – Aug 18) and 2013 (Jul 8-Aug 7)


Cairo
Holiday Lighting
Less
equal
more

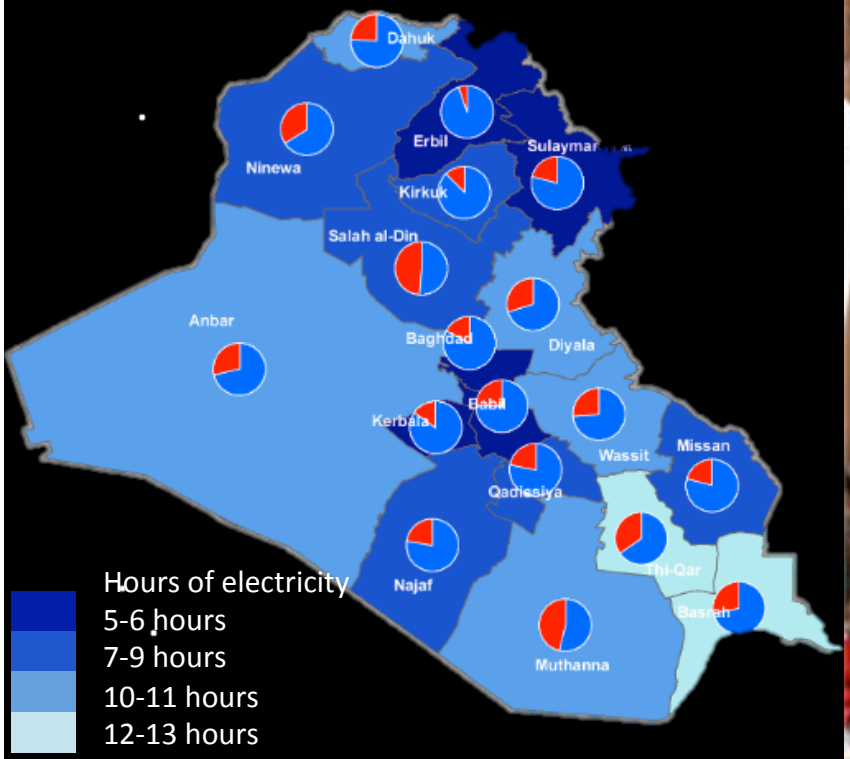
Patterns in energy behaviors across Egypt

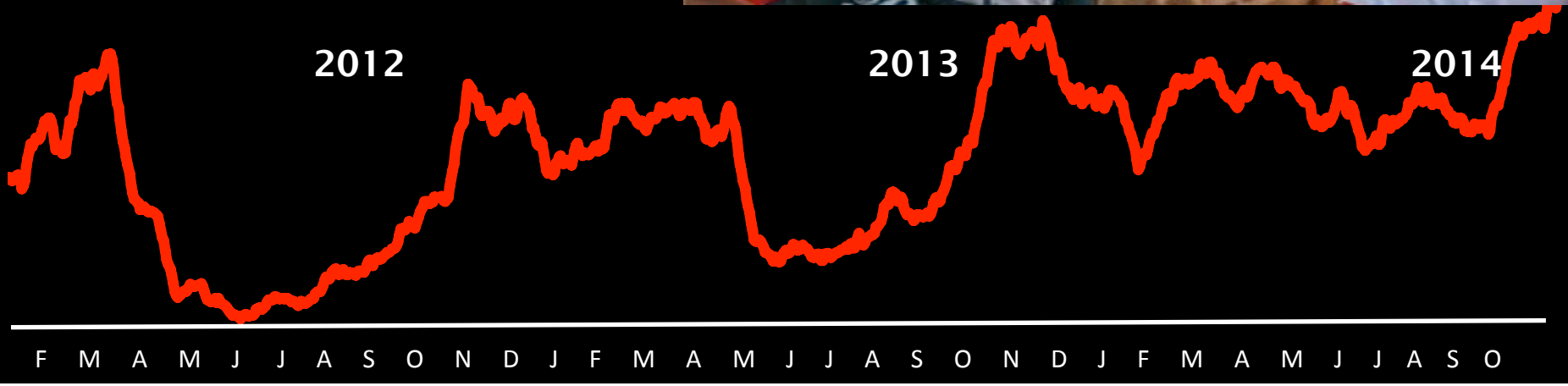




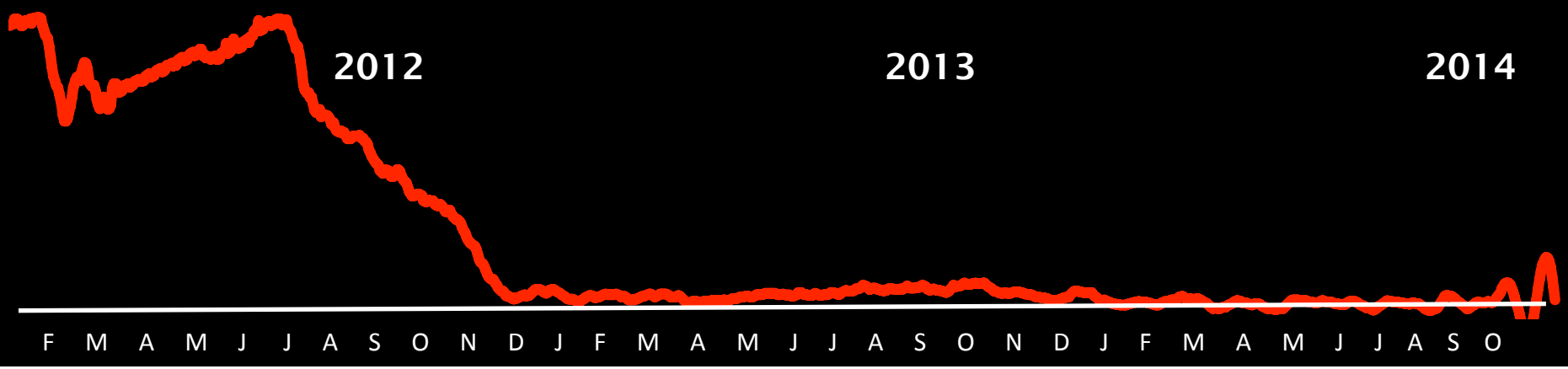
VIIRS can capture different levels of energy access—i.e., when and whether communities have access to energy services, and how intermittent that access is.

Basrah, Iraq


Dahuk
Ninewa
Erbil
Sulaymaniyah
Kirkuk
Salah al-Din
Anbar
Baghdad
Diyala
Babil
Kerbala
Wassit
Missan
Qadissiya
Najaf
Thi-Qar
Basrah
Muthanna
Hours of electricity
5-6 hours
7-9 hours
10-11 hours
12-13 hours


2012
2013
2014
F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O

Aleppo, Syria



Recommendations for future dynamic mapping projects:

1. Observation across cities
2. Fully utilizing the time dimension
3. Fusing new data sets
4. Bringing together place and process
5. Science + policy