### Mapping Density with Intensity: Spatial Disaggregation of Gridded Population Density using Stable Night Light Brightness

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### Imaging Night Light from Space

Comparison of Night Light & Population Density

Disaggregation of Population Density using Night Light

A Gallery of Nocturnal Lightscapes

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# VIIRS

The Visible Infrared Imaging Radiometer Suite (VIIRS) is the primary imaging sensor flown on the NASA/NOAA Suomi National Polar Partnership satellite.

Launched on October 28, 2011, VIIRS began to collect usable data in late-February 2012.

22 spectral channels, most with 750 meter pixels at nadir.

3000 km swath. Overpasses at ~01:30 and 13:30 daily.

VIIRS collects global low light imaging data at night in a single spectral band spanning visible to near infrared.

NOAA-NCEI Earth Observation Group produces monthly night light composites from 1/2014 - Beta versions from 2012 & 2013 also available.

### Night Light Sensor Comparison

	Legacy	Next Generation
Satellite	USAF DMSP	NASA-NOAA Suomi NPP
Sensor	OLS	VIIRS
Footprint	$5000^2 \text{ m}^2$	$742^2 \text{ m}^2$
Quantization	6 bit	14 bit
Calibrated	No	Yes
Multispectral	No	Yes
Detection Limit	Low	Very Low
Duration	1992-2013 (5 sensors)	2012-Present

Due to its higher resolution and dynamic range and lower detection limit, VIIRS can detect smaller, dimmer lights than OLS without saturating bright lights. Our objective is to quanitfy the difference.



Source: www.ngdc.noaa.gov/eog Analysis: www.LDEO.columbia.edu/~small/UrbanPopLight



<b>+</b>	10°	Population Density	104
N	10°	Brightness	10 <sup>2</sup>

Source: www.sedac.ciesin.columbia.edu Analysis: www.LDEO.columbia.edu/~small/UrbanPopLight



### Population Density 2010

	10°	Population Density	104
N 10°		Brightness	10 <sup>2</sup>

10°Population Density10410°Brightness102

### VIIRS dnb 2012

ource: www.ngdc.noaa.gov/eog nalysis: www.LDEO.columbia.edu/~small/UrbanPopLight



Population Density 10<sup>4</sup> Brightness 10<sup>2</sup>

 $10^{\circ}$ 

10°

### Population Density 2010

Source: www.sedac.ciesin.columbia.edu Analysis: www.LDEO.columbia.edu/~small/UrbanPopLigh



VIIRS dnb 2012 Source: www.ngdc.noaa.gov/eog Analysis: www.LDEO.columbia.edu/~small/UrbanPopLight

•	10°	Population Density	104
Ň	10°	Brightness	10 <sup>2</sup>



↑ 10° N 10°	10°	Population Density	104
	10°	Brightness	10 <sup>2</sup>



Population Density 2010 Source: www.census.gov Anatysis: www.LDEO.columbia.edu/-smallUrbanPopLight

10° People/km<sup>2</sup>

10<sup>5</sup>

![](_page_11_Picture_0.jpeg)

![](_page_12_Picture_0.jpeg)

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## Illinois & Wisconsin

![](_page_13_Picture_1.jpeg)

# Southern California

![](_page_14_Picture_1.jpeg)

## Paraná

![](_page_15_Picture_1.jpeg)

## Bahia

![](_page_16_Picture_1.jpeg)

## Strategy

1) Use spatial correspondence between VIIRS night light and high spatial resolution census data to *develop Intensity:Density tranfer functions*.

2) Use Intensity:Density transfer functions to disaggregate lower resolution census data. Relocate fraction of administrative area population into lighted areas and reduce background population density accordingly.

3) Use variability in Intensity:Density distributions to estimate quantile uncertainty bounds. Result: Disaggregated lower, Median, upper bounds.

**Principal Benefits: Simplicity Tranparency Reproducability** 

### Estimation of Population-Luminance Transfer Functions

![](_page_18_Figure_1.jpeg)

## Conclusions

VIIRS provides significantly higher spatial resolution and dynamic range than DMSP-OLS night ligths. *Detects small dim lights. e.g. vehicles & boats* 

VIIRS overglow is considerably reduced compared to OLS - but still present.

VIIRS shows excellent qualitative agreement to population density in high spatial resolution census data - but *cannot represent sparse rural populations*.

VIIRS shows greatest disagreement with census data in industrial areas with extensive outdoor lighting and low resident population densities - *as expected*.

Disagreement between light & population. density also results from uncertainty in true population distribution within larger administrative units.

Intensity:Density transfer function varies within & among countries but quantile bounds capture majority of variability. *Bounds yields uncertainty estimates*.

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![](_page_19_Picture_10.jpeg)

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![](_page_20_Picture_0.jpeg)

# Log<sub>10</sub> Luminance (nW/cm<sup>2</sup>/sr)

# Log<sub>10</sub> Population Density (people/km<sup>2</sup>)

![](_page_21_Picture_0.jpeg)

![](_page_22_Picture_0.jpeg)

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