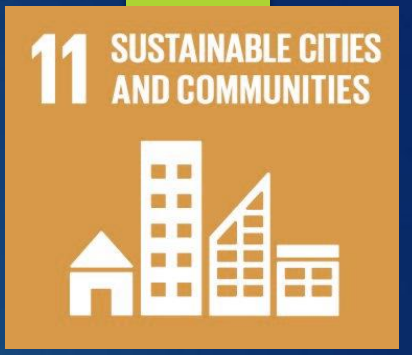
Impact assessment of **socio-economic development** on **urban air quality** in Indian mega cities



7/17, 2017

LCLUC SARI INTERNATIONAL REGIONAL SCIENCE MEETING IN S./SE. ASIA

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Contents

- Previous results
- STIRPAT model
- AirRGB decomposition
- Urban morphology
- Future course

Traffic congestion, New Delhi

Clear Day

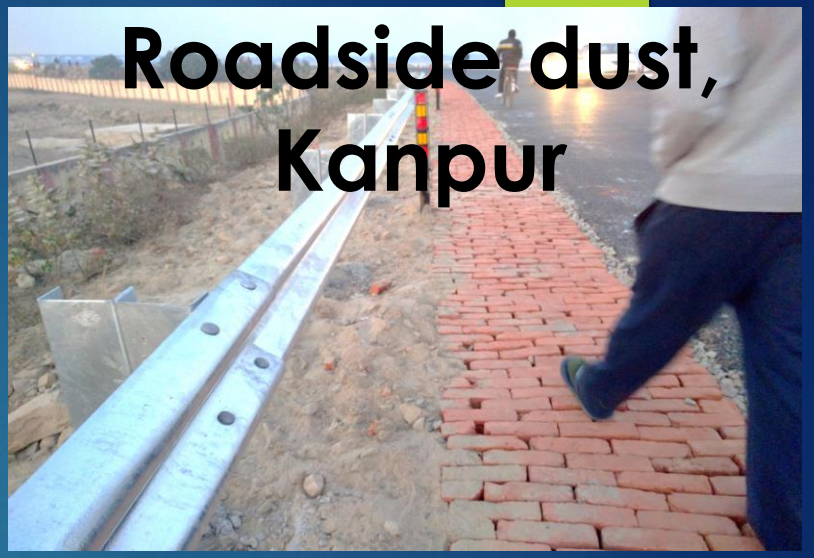
Hazy Day

Municipal waste Varanasi

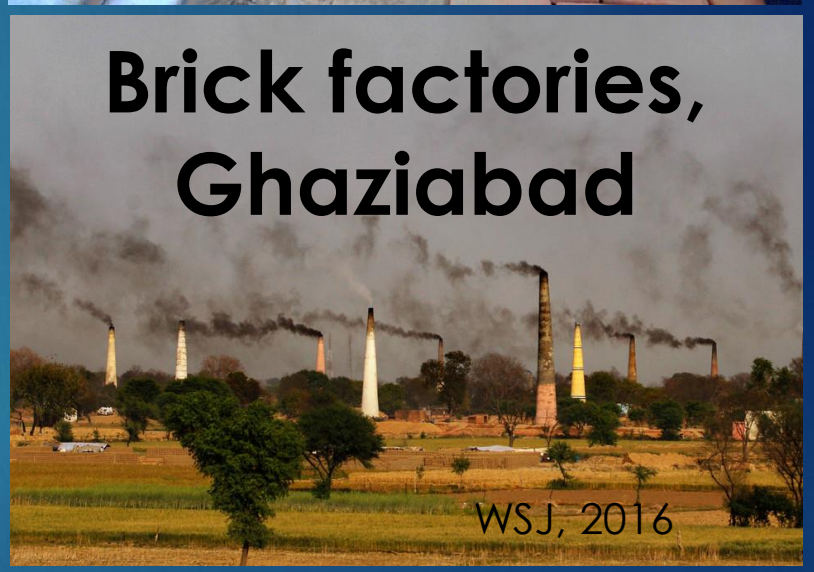
HT, 2016

Industrial emission, Lucknow

Roadside dust, Kanpur



Brick factories, Ghaziabad



WSJ, 2016

DNA, 2017

Traffic co

New

20 Dec, 201

21 Dec, 201

dust,

our

tories,

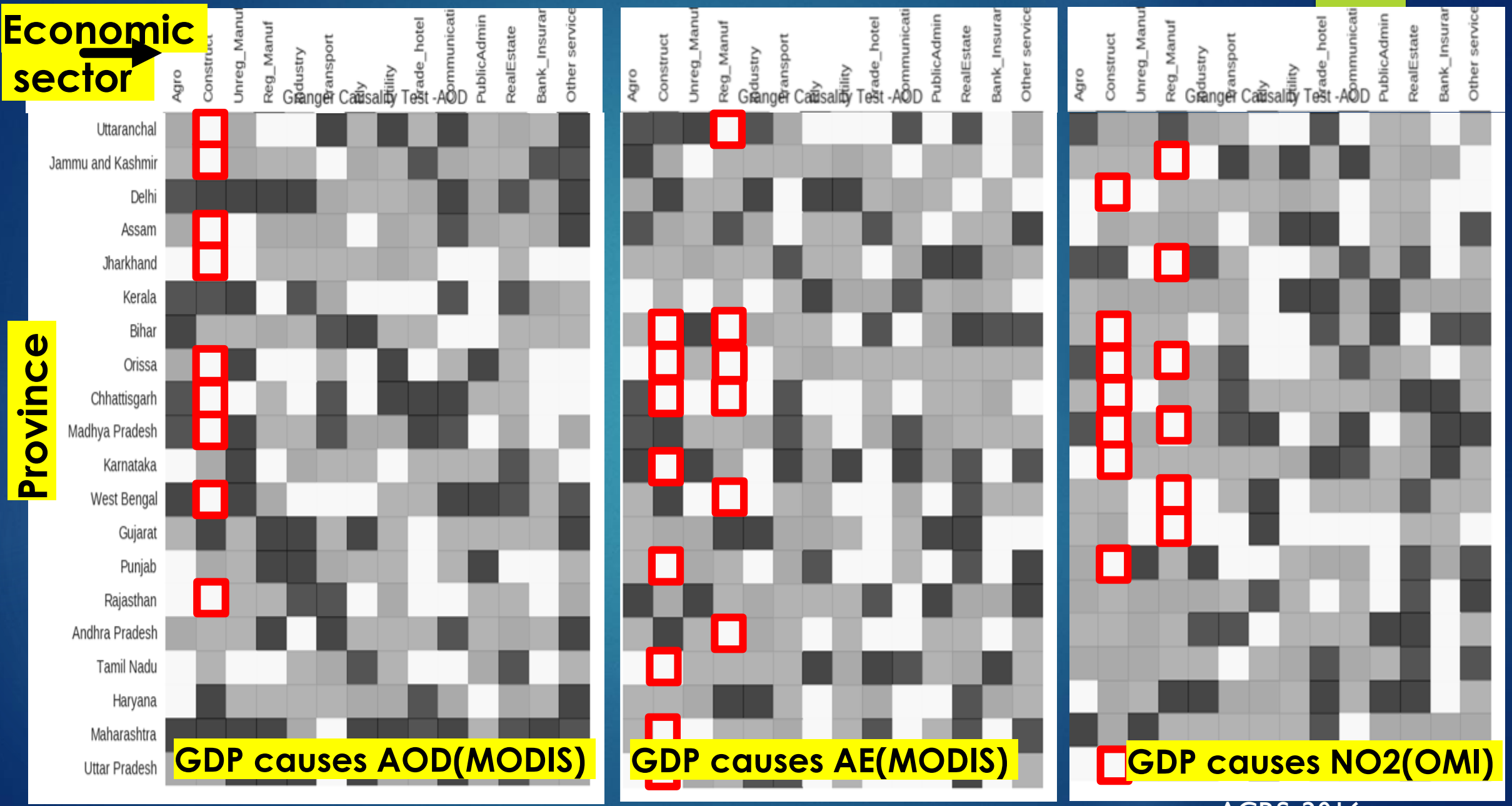
bad

WSJ, 2016

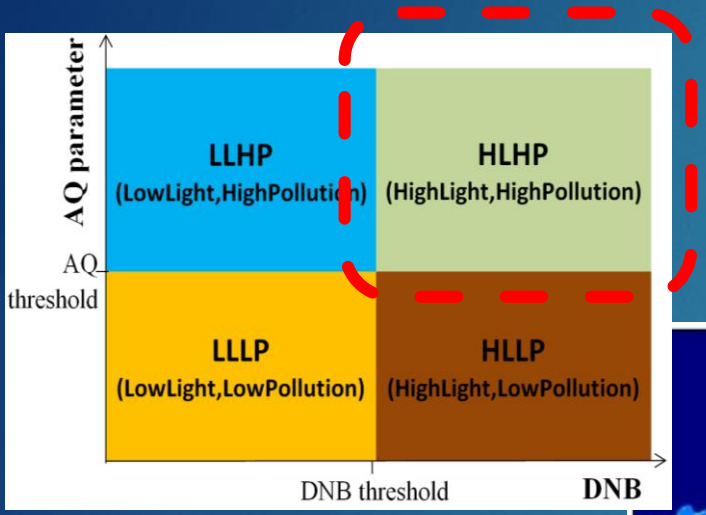
, 2017

40% (1.2million person) global mortality

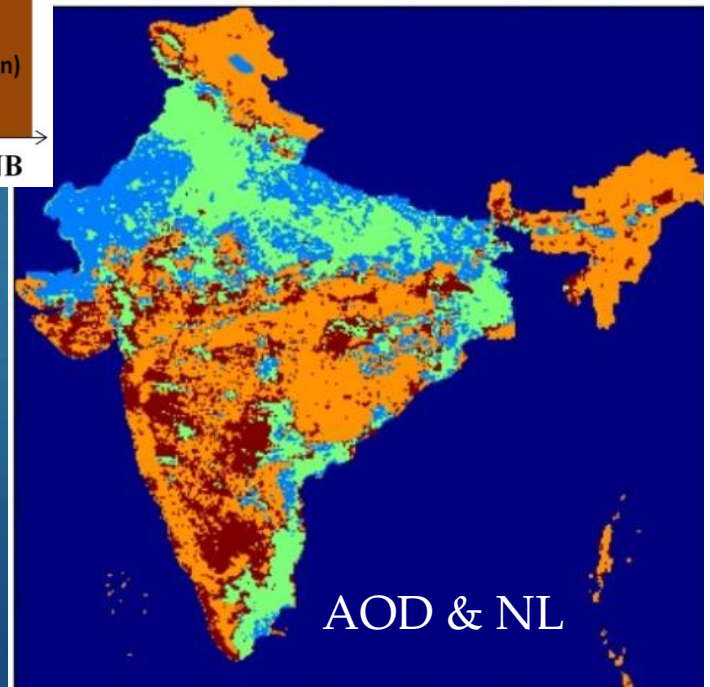
Industrial, construction GDP growth Granger causes pollution

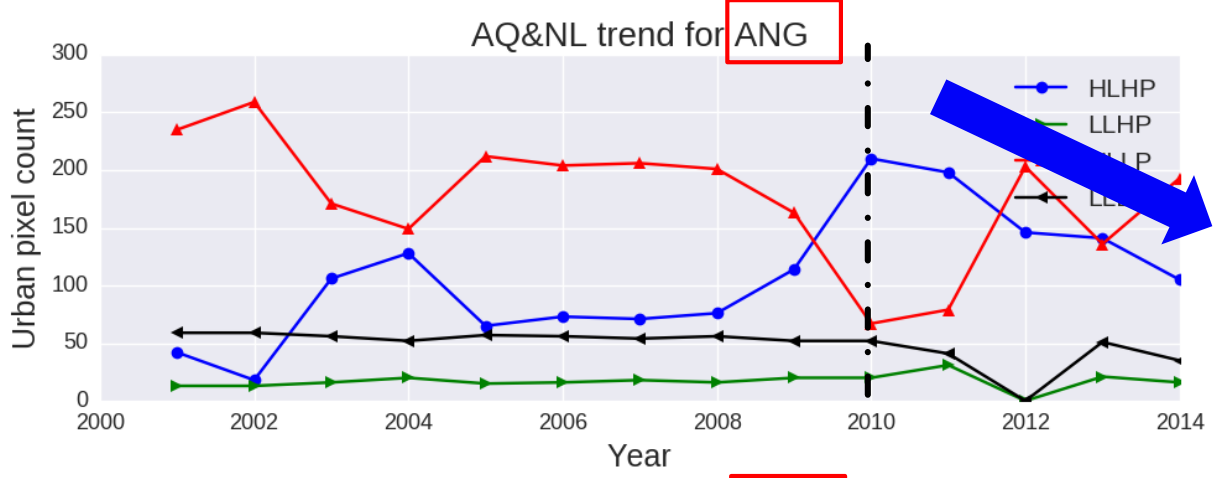


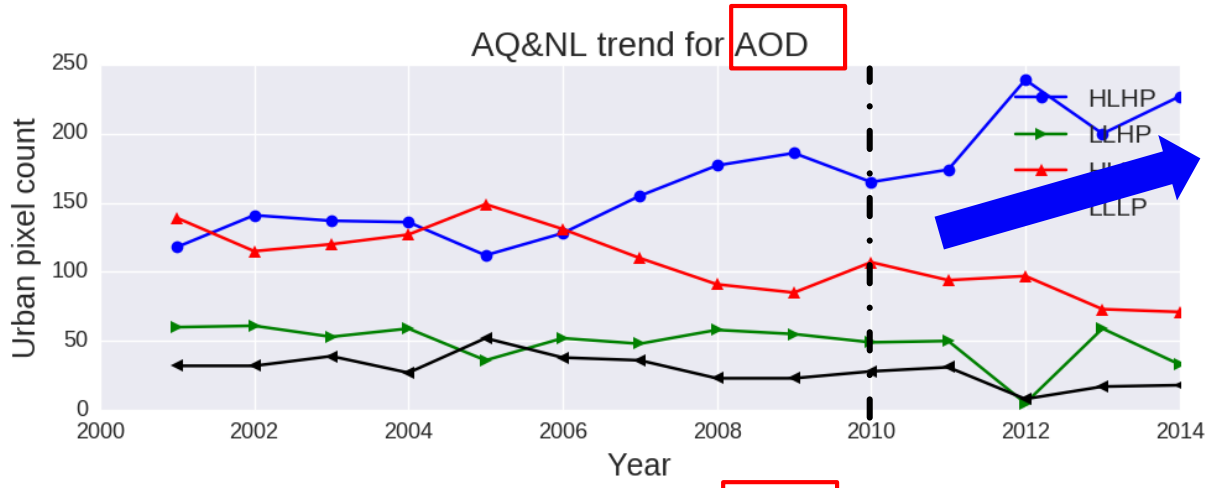
Nightlight characteristics can differentiate emission causes

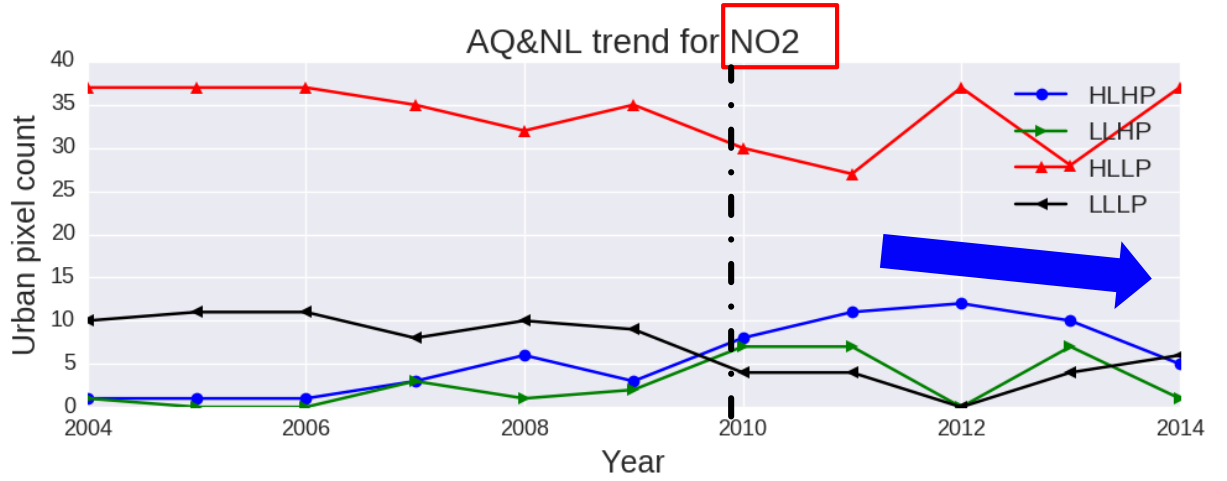


AQ-NL Classification
(Misra&Takeuchi, IGRSM, 2016)









High correlation **of built-area, population** with urban pollutants growth

	Urban area	Urban area growth ('02-'15)	Population ('11)	Population growth ('01-'11)	ANG growth ('10-'15)	AOD growth ('10-'15)	SO_2 growth ('09-'14)	NO_2 growth ('09-'14)
Urban area	1.00							
Urban area growth	0.08	1.00						
Population	0.01	-0.28	1.00					
Population growth	0.50	-0.23	-0.04	1.00				
ANG growth	0.59	0.08	-0.17	0.64	1.00			
AOD growth	0.90	0.08	0.19	0.37	0.52	1.00		
SO_2 growth	0.10	-0.24	-0.53	0.31	0.12	-0.22	1.00	
NO_2 growth	-0.34	0.35	-0.05	-0.30	-0.07	-0.39	0.01	1.00

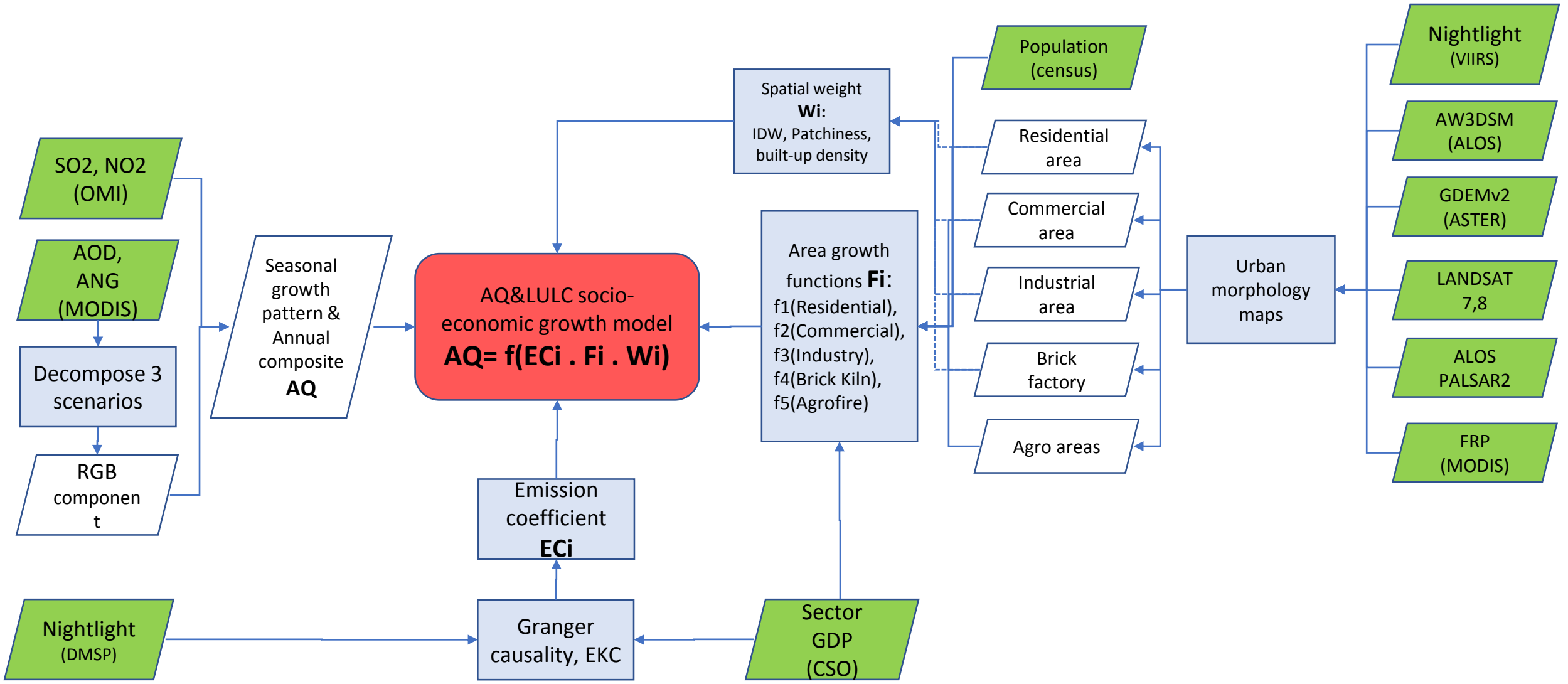
Hypothesis

- Socio-economic development (from Remote Sensing) impacts air urban air quality

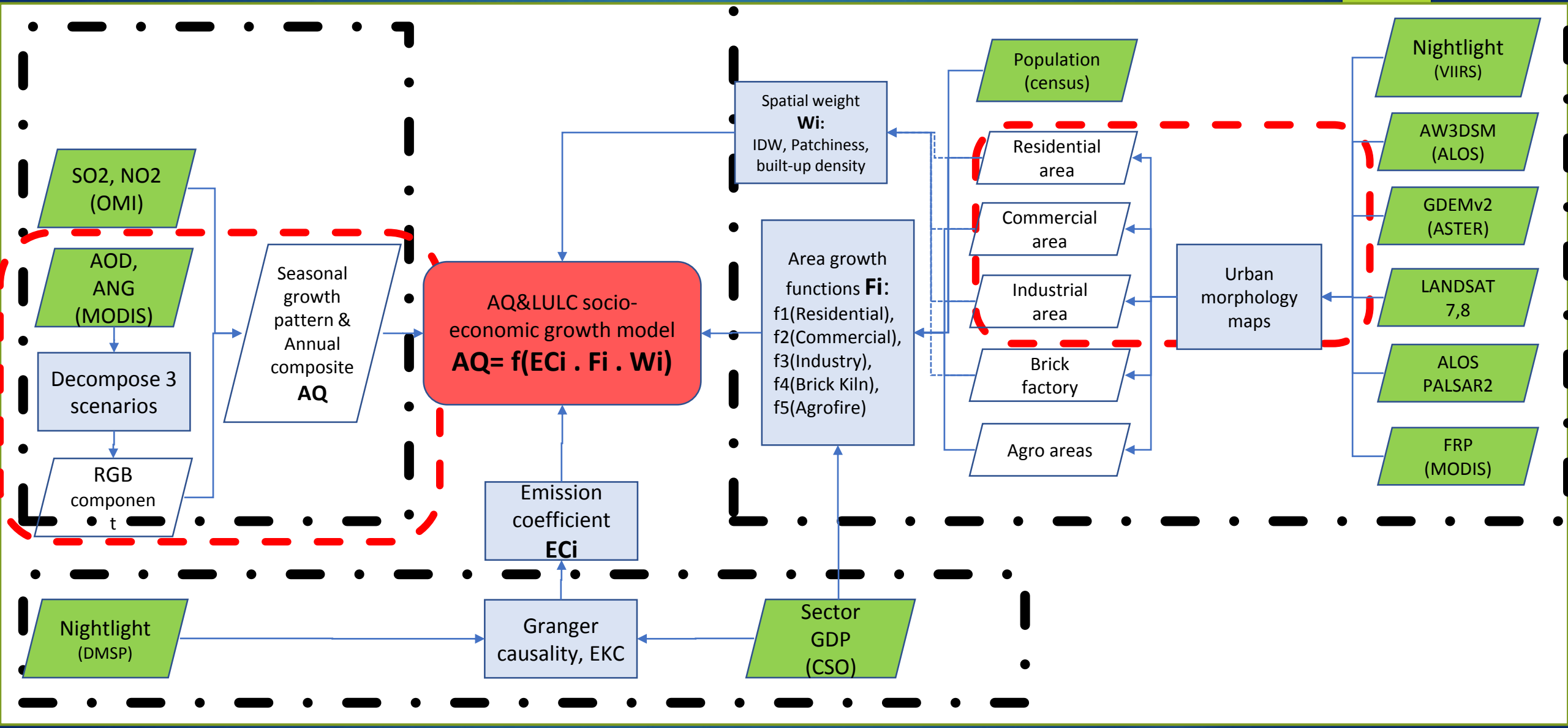
Objective

- Assess impact of socio-economic development and land-use land-cover change on urban air quality

Incorporating Socio-economic development

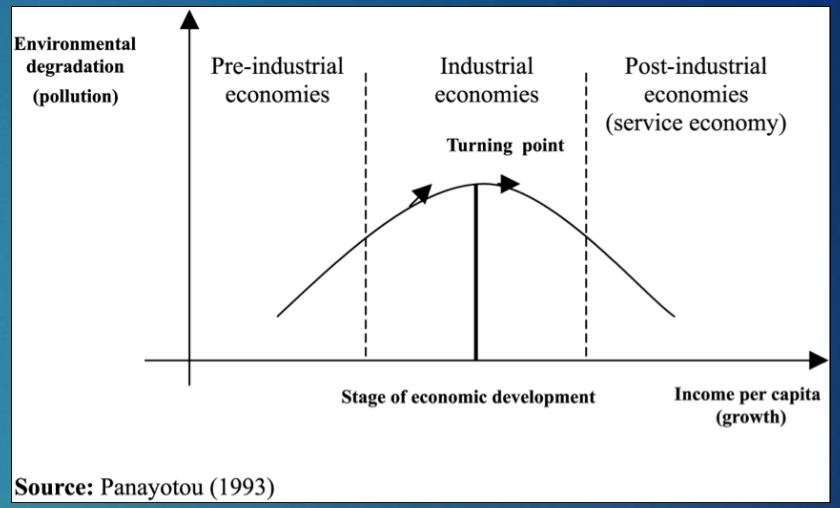


Incorporating Socio-economic development



How Socio-economic growth impacts urban air pollution?

- **Environmental Kuznet's Curve**
  (Kuznet, 1955; Panayotou, 1993)



Source: Panayotou (1993)

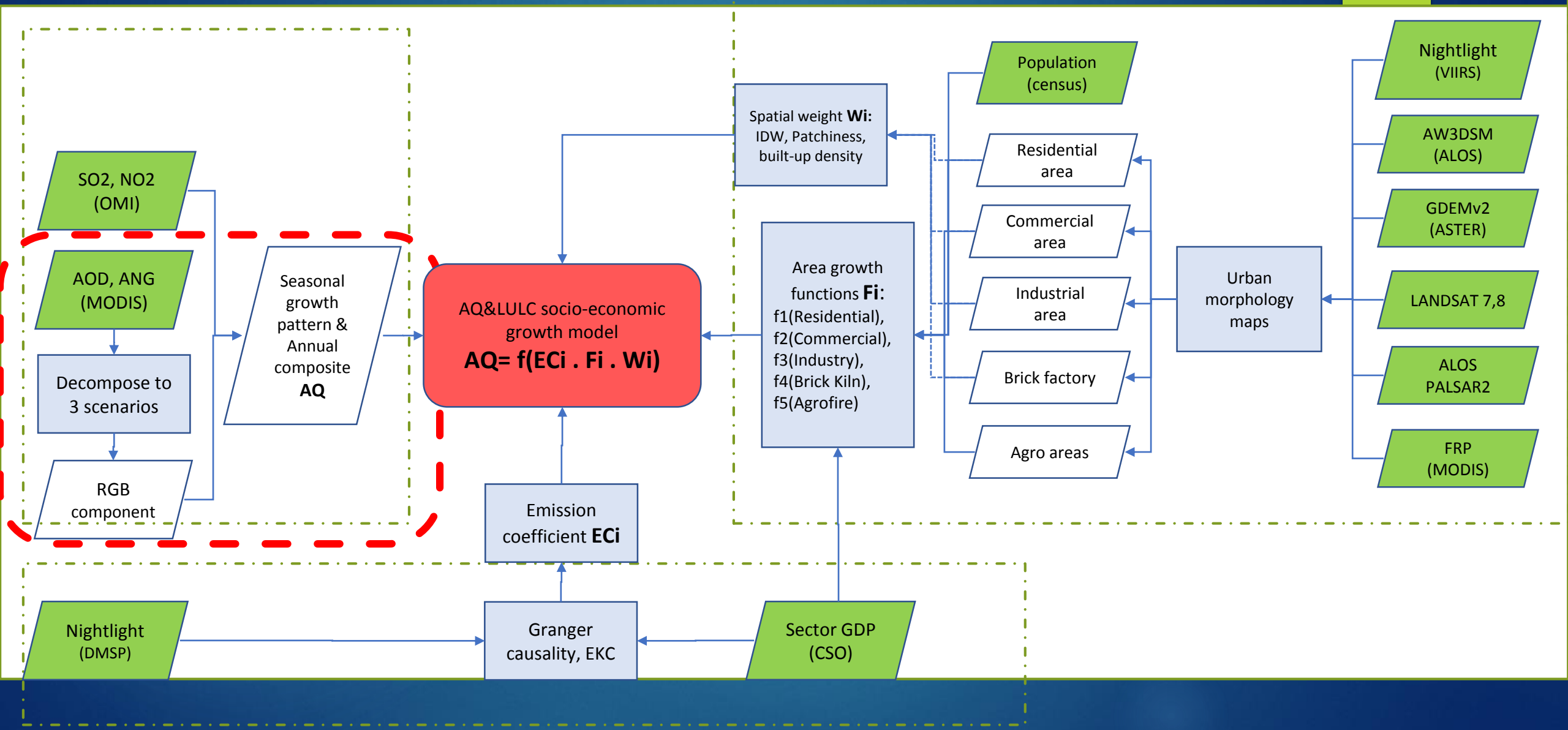
- **IPAT Equation**
  (Ehrlich & Holdren, 1976)

I = PAT
I – Impact
P – Population
A - Affluence
T - Technology

- **STIRPAT modification**
  (Dietz&Rosa, 1997)

: $I = P^a A^b T^c$

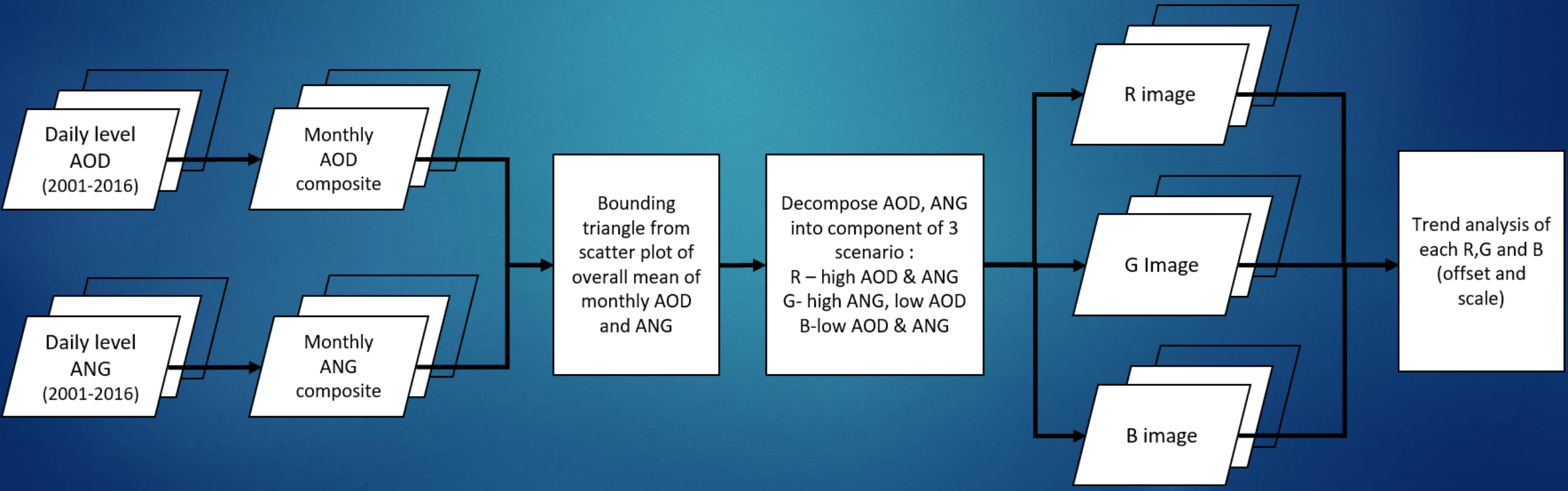
AirRGB decomposition



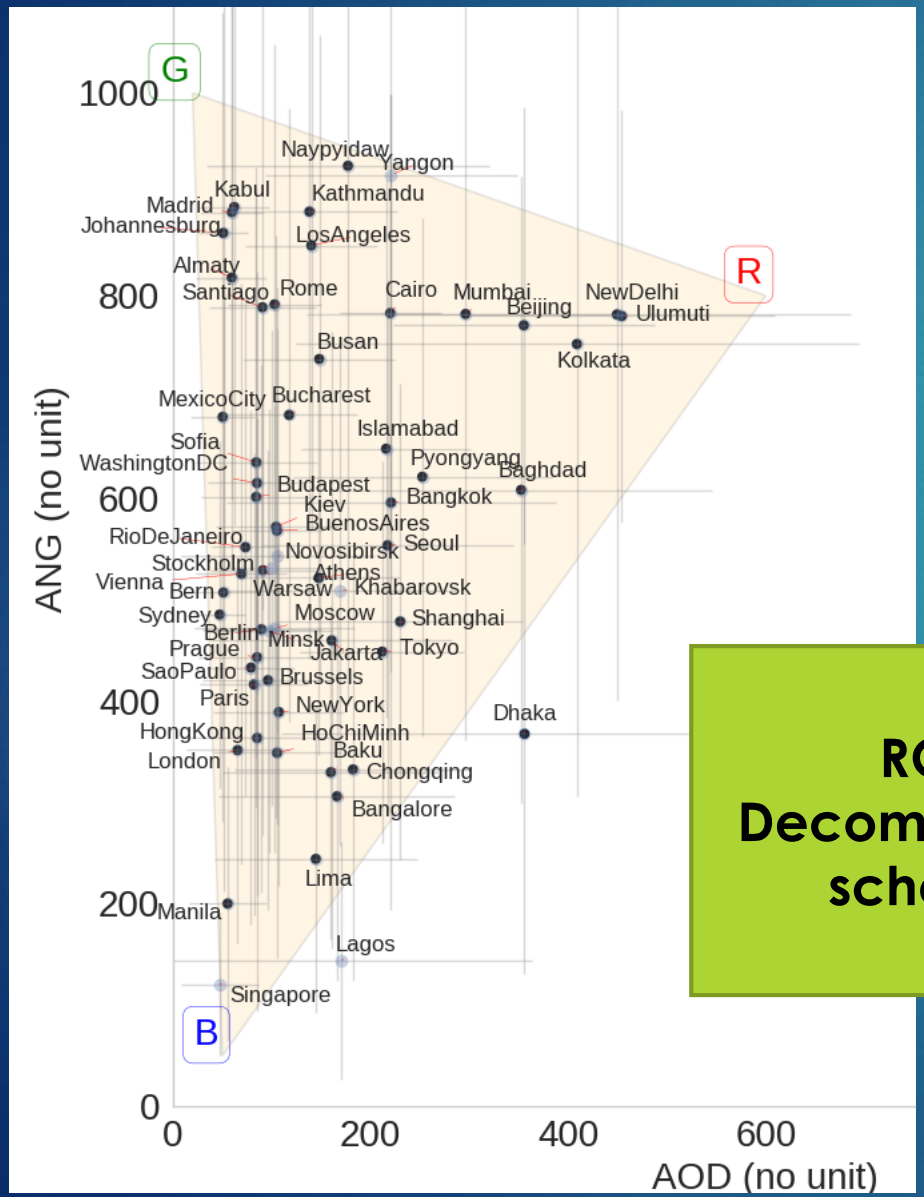
1. AirRGB – analyze anthropogenic urban pollution

(ACRS 2013; Misra et al, Under review)

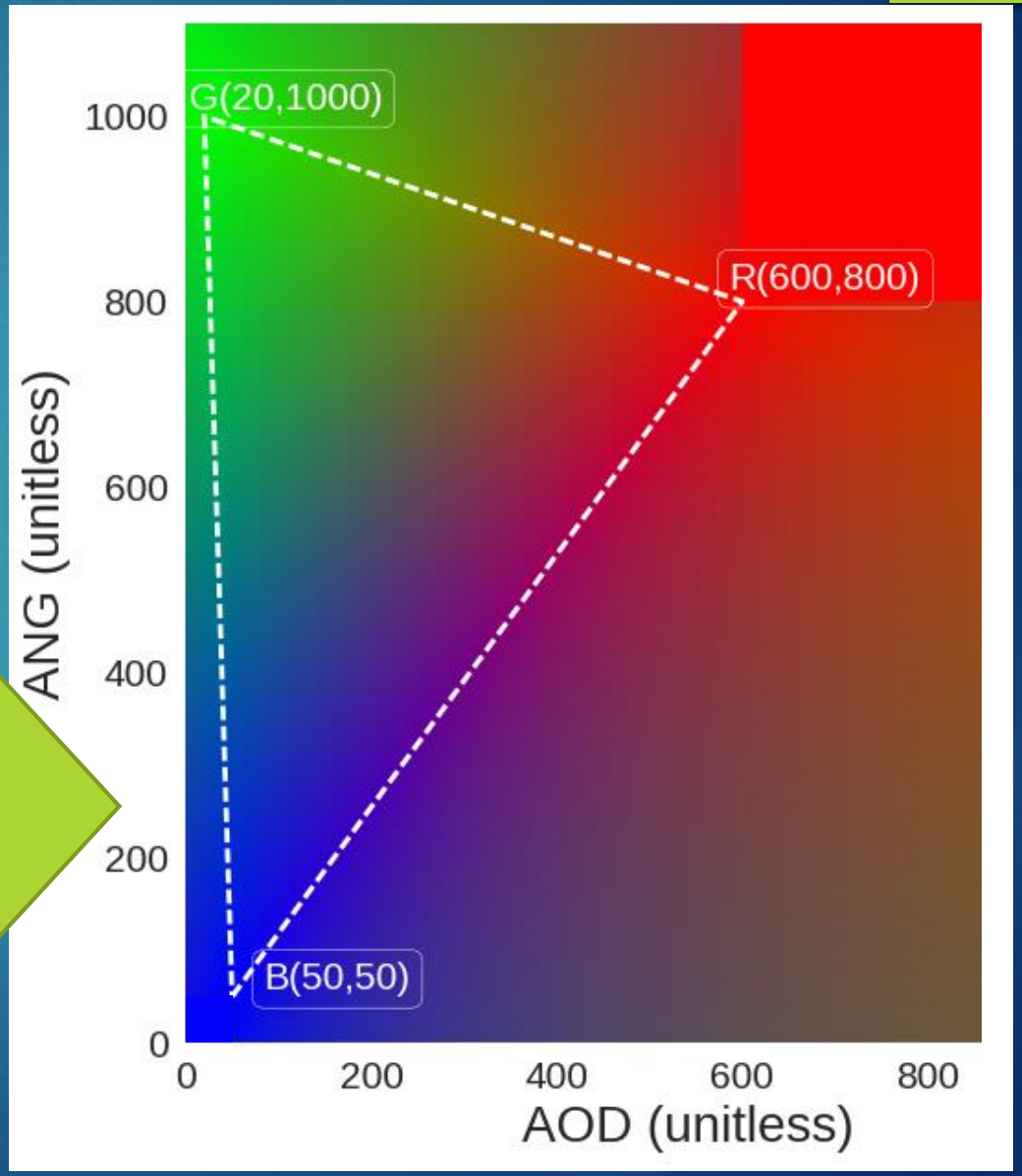
- Consider AOD, ANG from MODIS across 60 cities globally (2001- 2016)



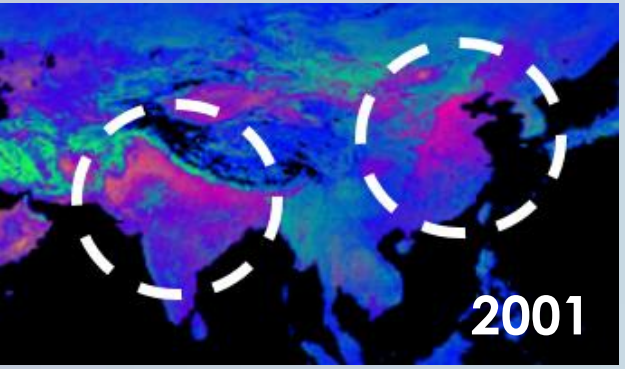
AirRGB scale for scenario estimation

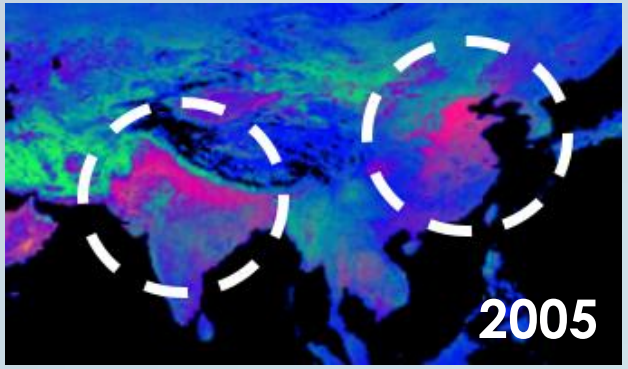


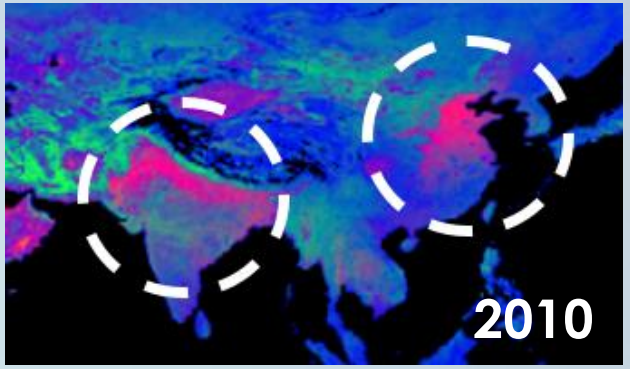
RGB Decomposition scheme

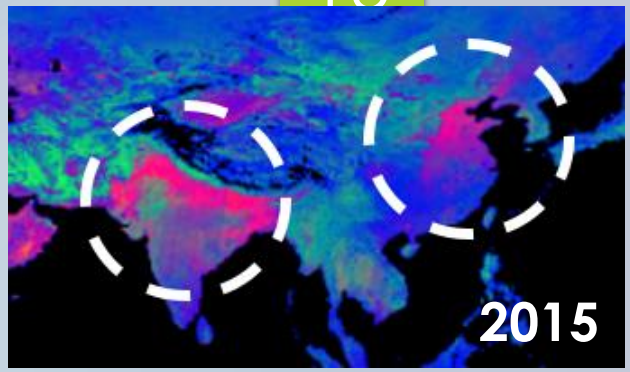


Rising pollution across North India



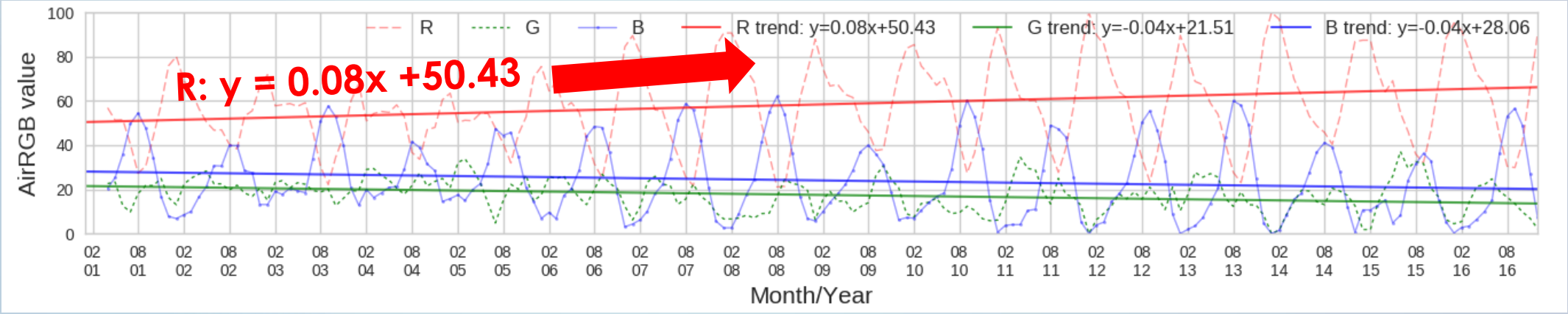




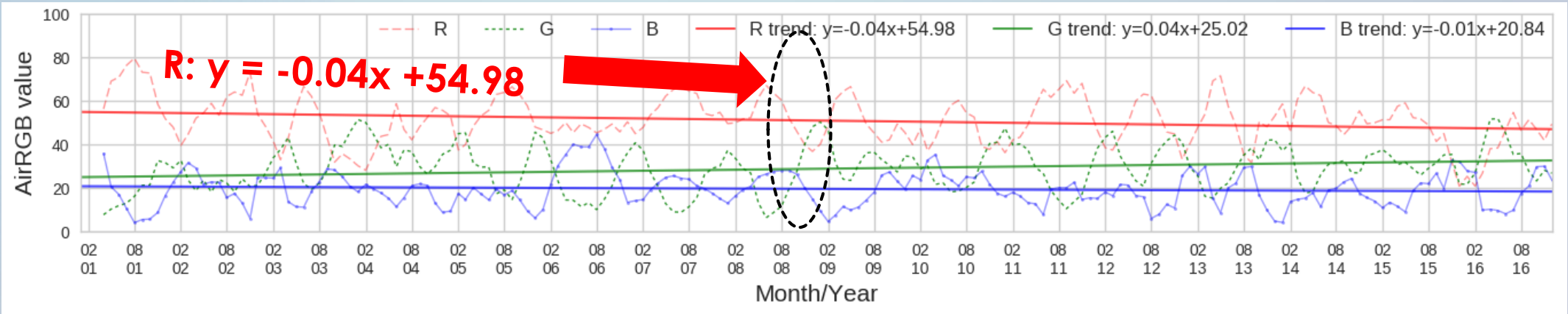


AirRGB map

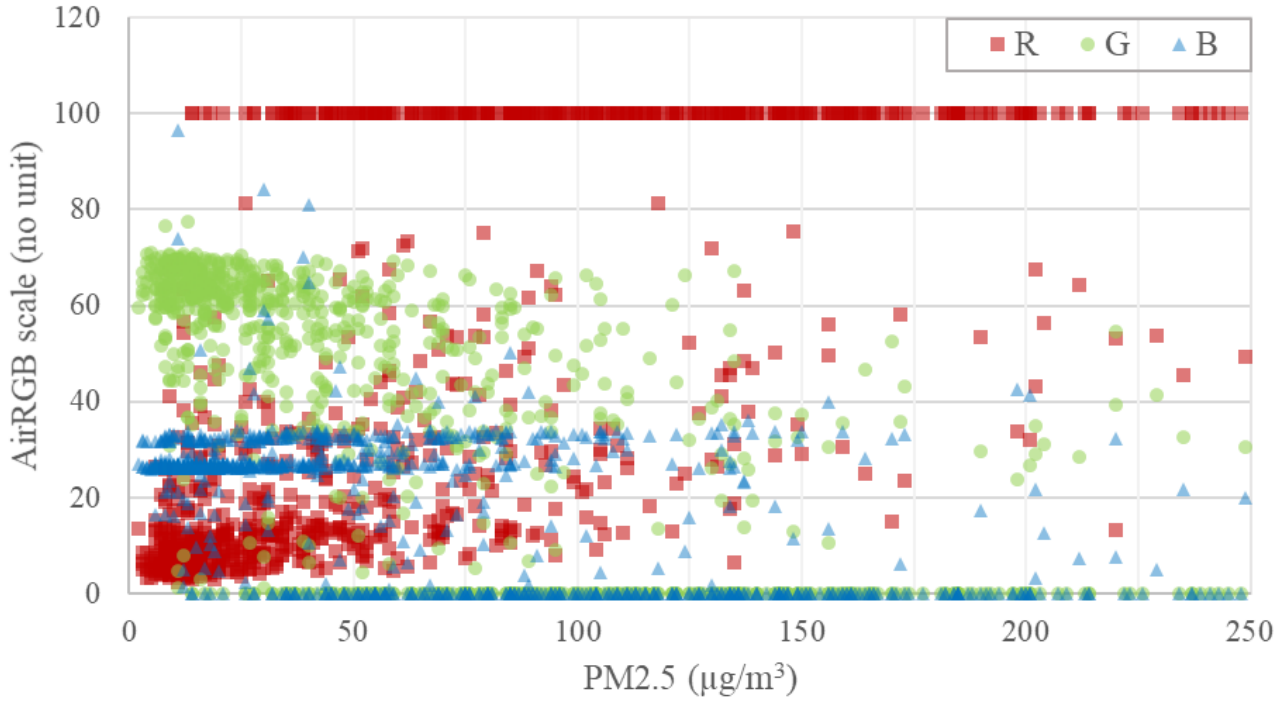
New Delhi

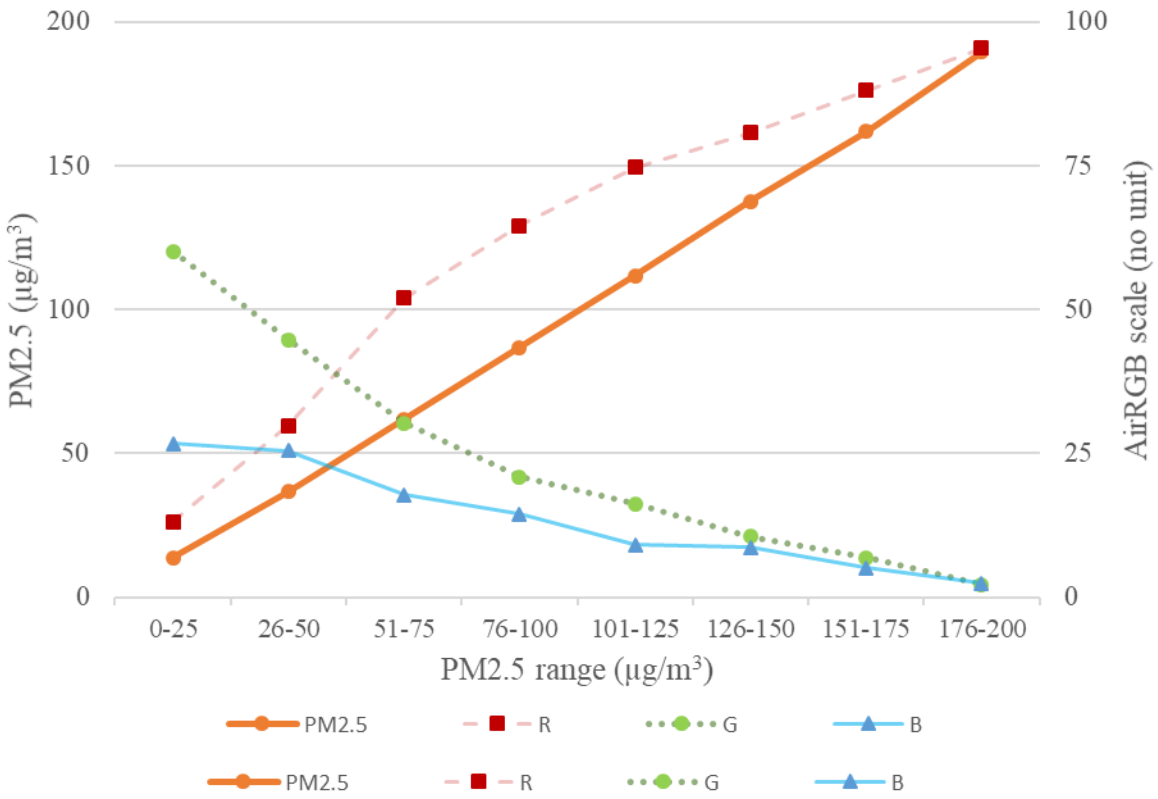


Beijing

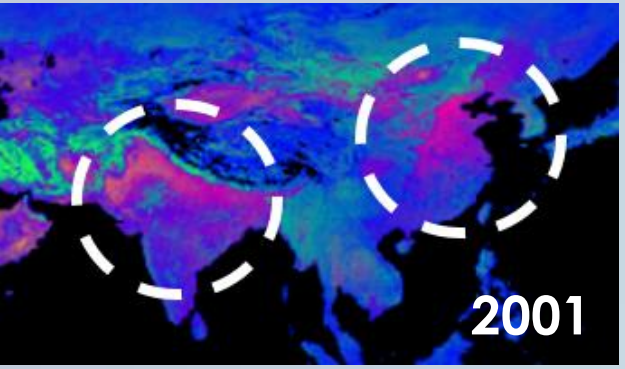


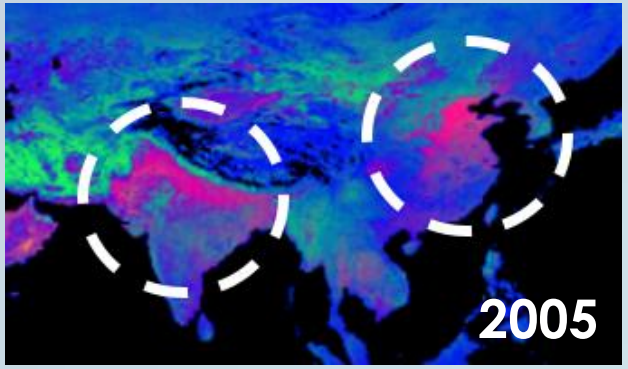
Validation with US Embassy monitor, Beijing. More required.

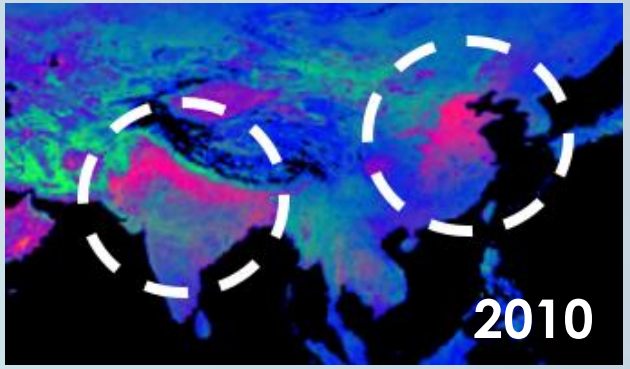


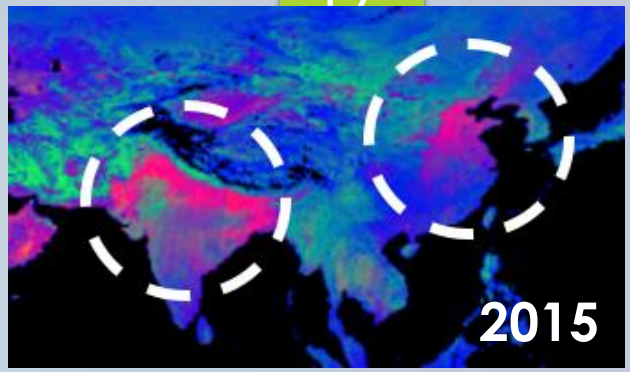


Rising pollution across North India

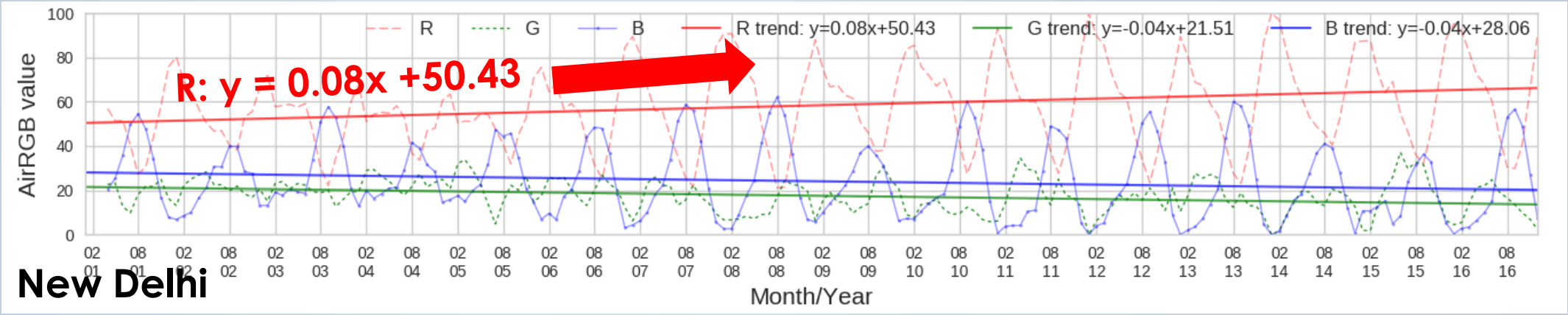






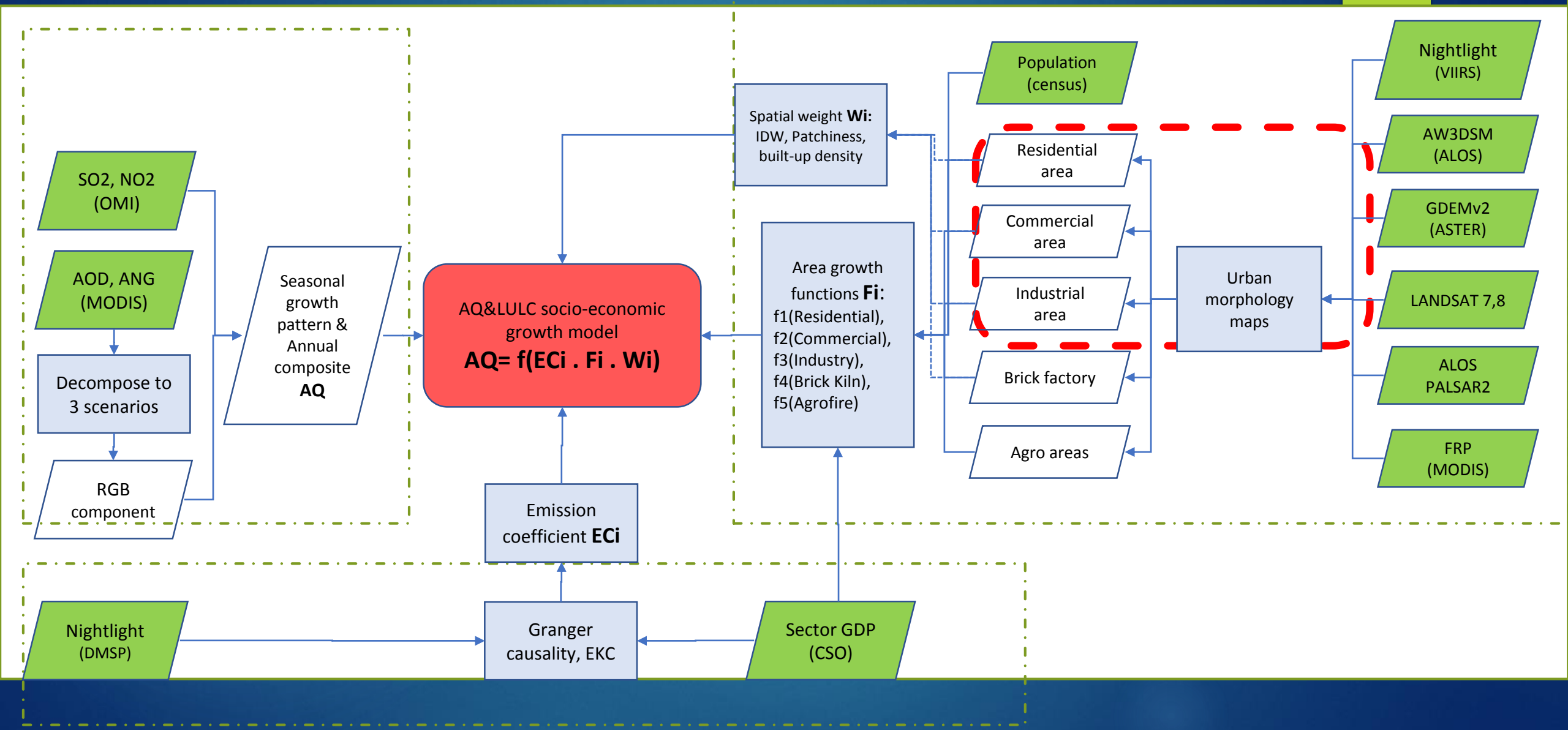


AirRGB map



What is causing rise in emissions?

Urban Morphology



2. Urban morphology affects air quality

Clark et al2011, Marquez & Smith,1999, Bertaud, 2009;

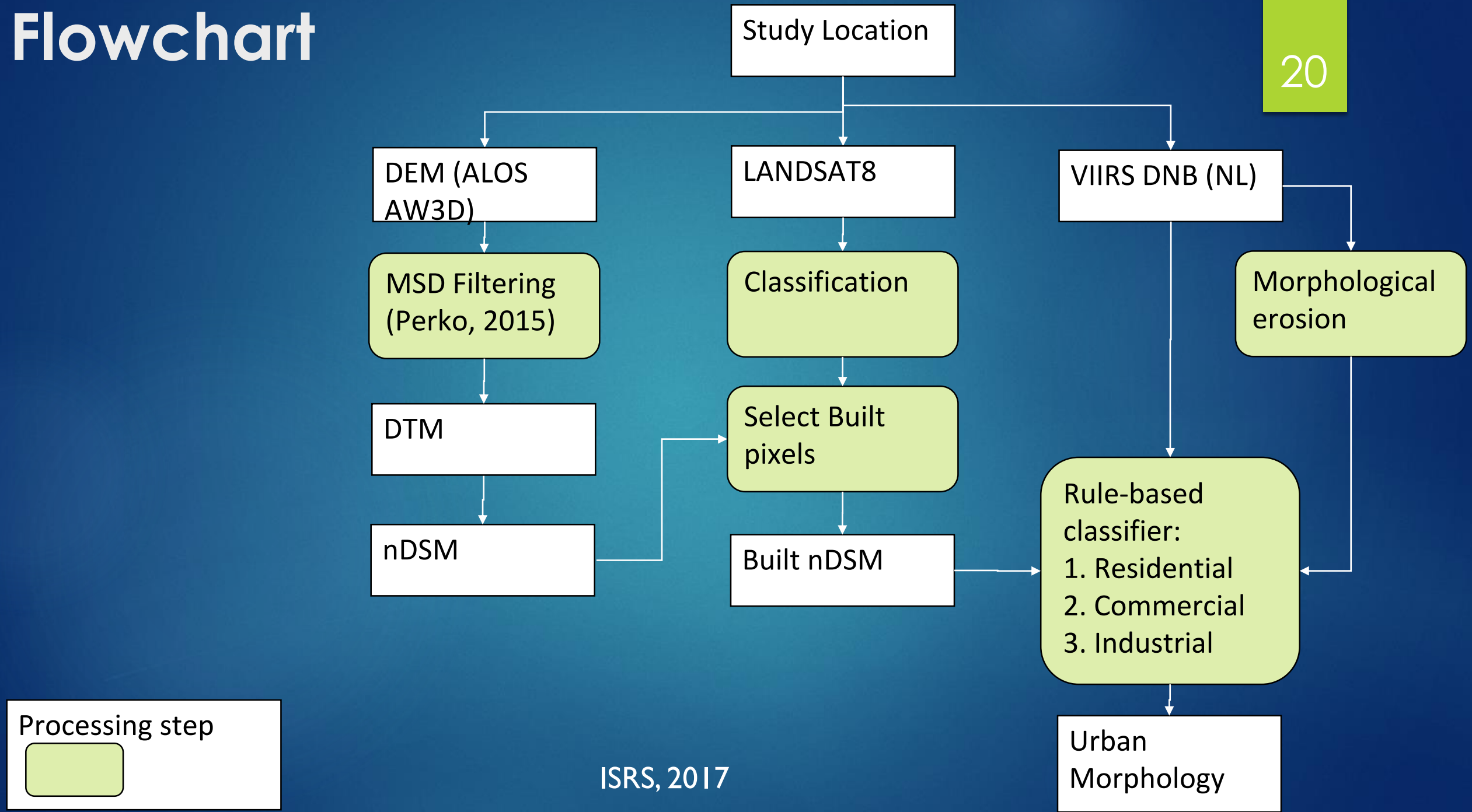
Livemnt, 2011

Residential area (Source:Panoramio)

Commerial area(Source:Flickr)

Industrial area(Source: TopCem)

Flowchart


Study Location
DEM (ALOS AW3D)
LANDSAT8
VIIRS DNB (NL)
MSD Filtering (Perko, 2015)
Classification
Morphological erosion
DTM
Select Built pixels
nDSM
Built nDSM
Rule-based classifier:
1. Residential
2. Commercial
3. Industrial
Urban Morphology
Processing step

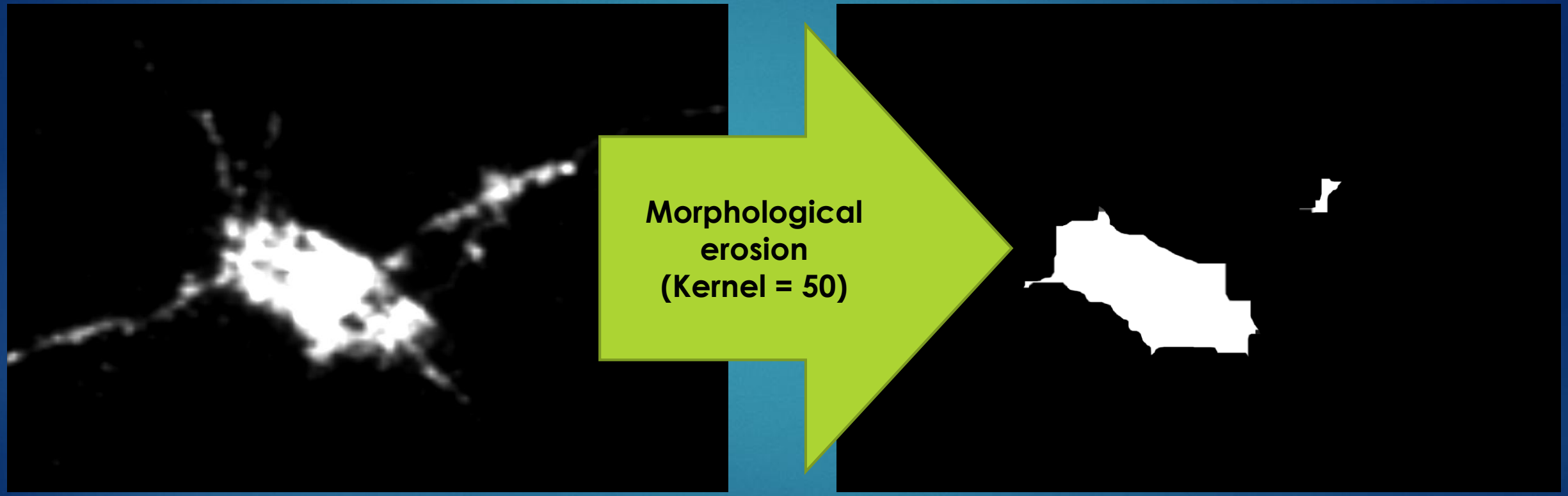
Datasets Used

DSM	▶ **AW3D**
Resolution	1'' (30m)
Acquisition	~2010-11
Platform	ALOS PRISM
Accuracy	5m (Tadono2015)

Other data	▶ **Landsat8 OLI**	▶ **VIIRS DNB**
Resolution	30m	15'' (450m)
Acquisition	Oct'13-Oct'14	Jan'14-Dec'14

‘urban core’ of Kanpur city

Assumption: Commercial building only within ‘core’



VIIRS DNB upsampled to 30m form 450m image

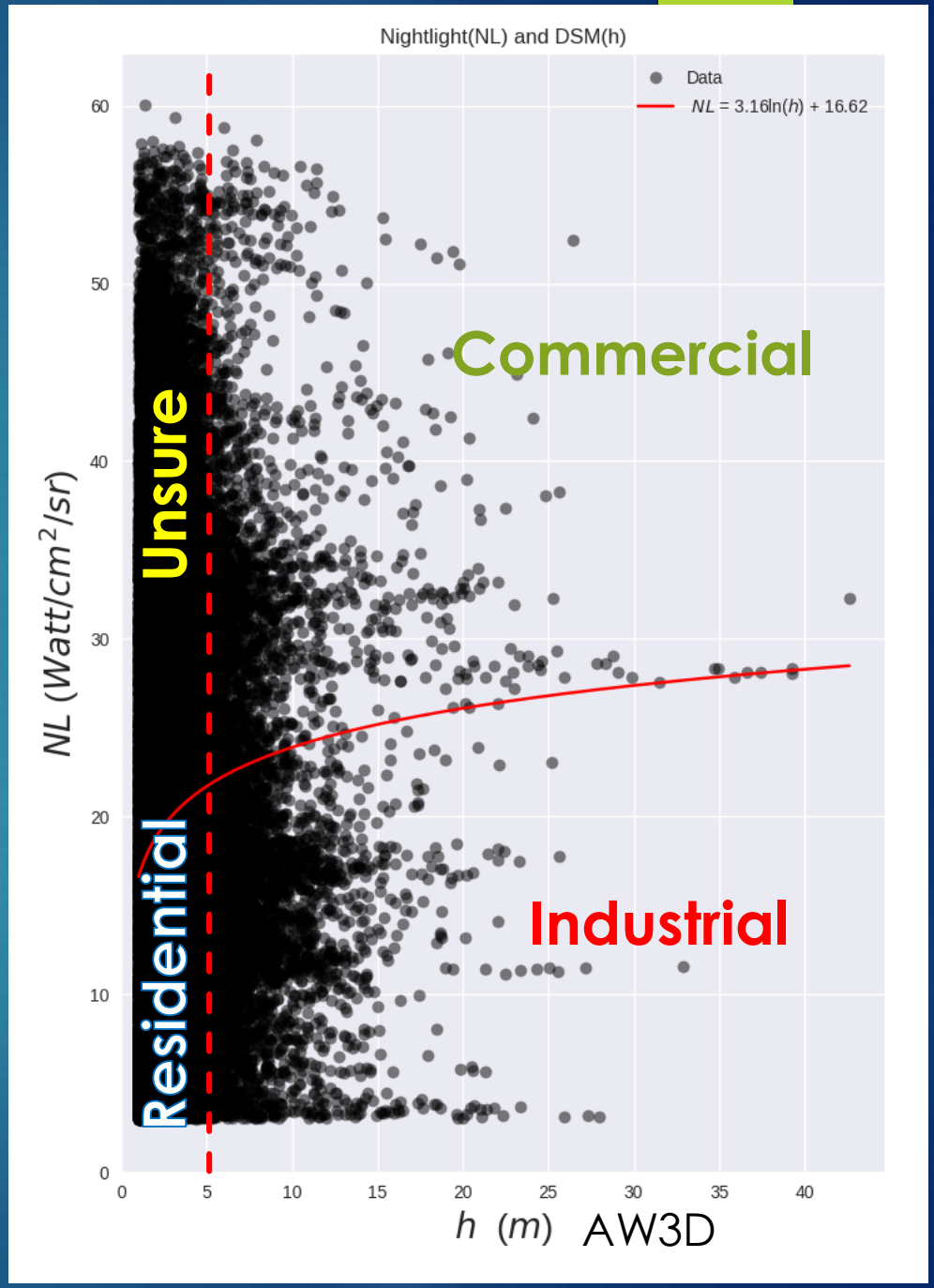
VIIRS DNB Eroded image and binary (>=2 Watt/cm2/sr)

h and NL rule classifier

NL' = f(*h*) = 3.16ln(*h*) + 16.62

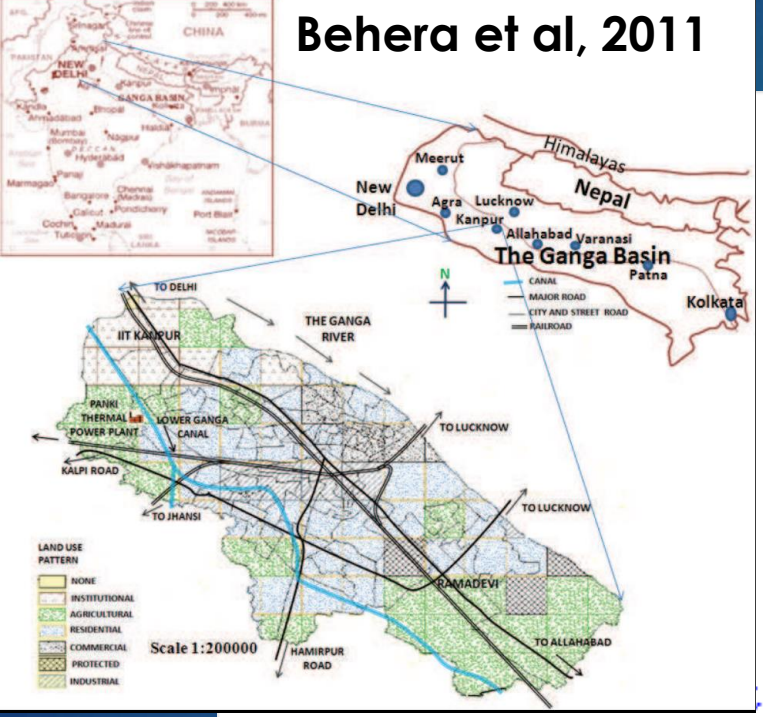
Thresholds:
height > = Municipal limit
NL >= **NL'**
Core = 1

Height	Nightlight	Core	Class
0	0	0	Residence
1	0	0	Industry
1	1	0	Industry
0	0	1	Residence
0	1	1	Unsure
1	0	1	Industry
1	1	1	Commercial



Urban morphological map – Kanpur city

Behera et al, 2011



Commercial

Residential

Industrial

2.5 0 2.5 5 7.5 10 km

Commercial

Residential

Industrial

TRUE

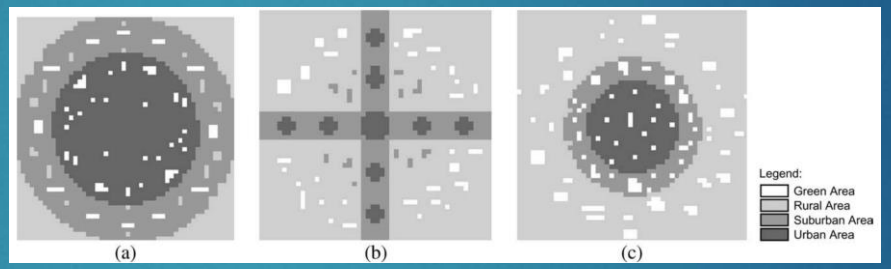
FALSE

Next Step- Identifying Brick Factories:

Future direction

- Urban morphology ~2000 (ASTER)
- Agricultural biomass burning (FRP), roadside dust
- Estimate emission factors and inventory

- City compactness:



Borrego, 2004

- CDR and mobility (Call data records)
- Citizen Science + Crowd Sourcing

Conclusion

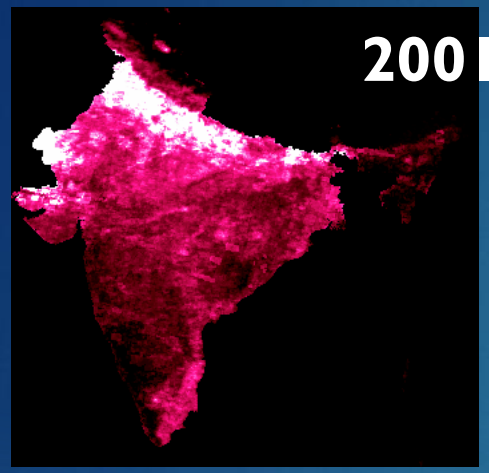
- Incorporate LCLUC in socio-economic model
- AirRGB decomposition can indicate anthropogenic aerosol from MODIS
- Urban morphology can be identified from AW3D and Nightlight
- Open and free data

Thank you for your kind attention

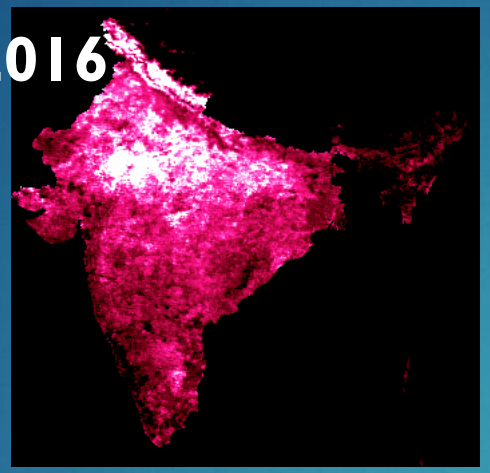
prakharmisra90@gmail.com; mprakhar@iis.u-tokyo.ac.jp

Brick factory identification

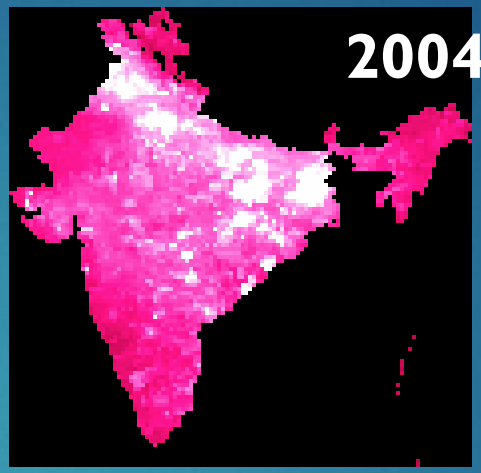
Worsening air quality in urban regions



AOD

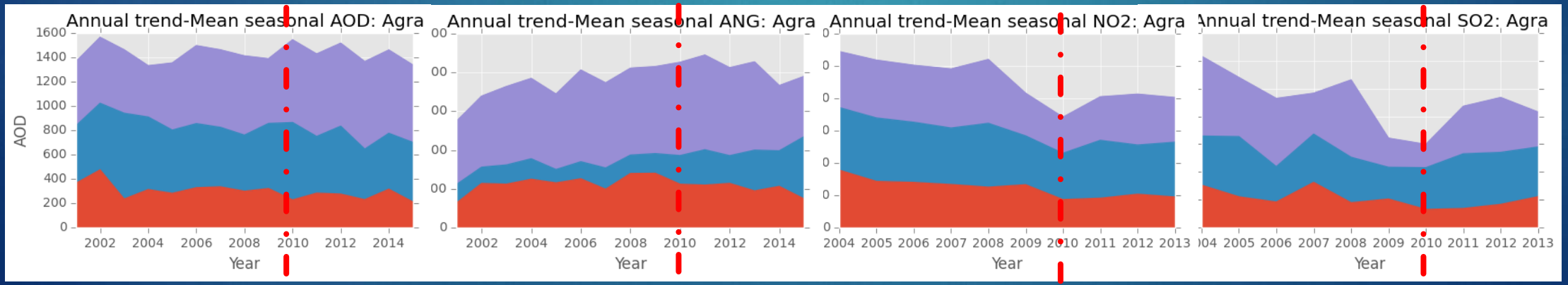


ANG



NO2

SO2



Misra & Takeuchi, 2015

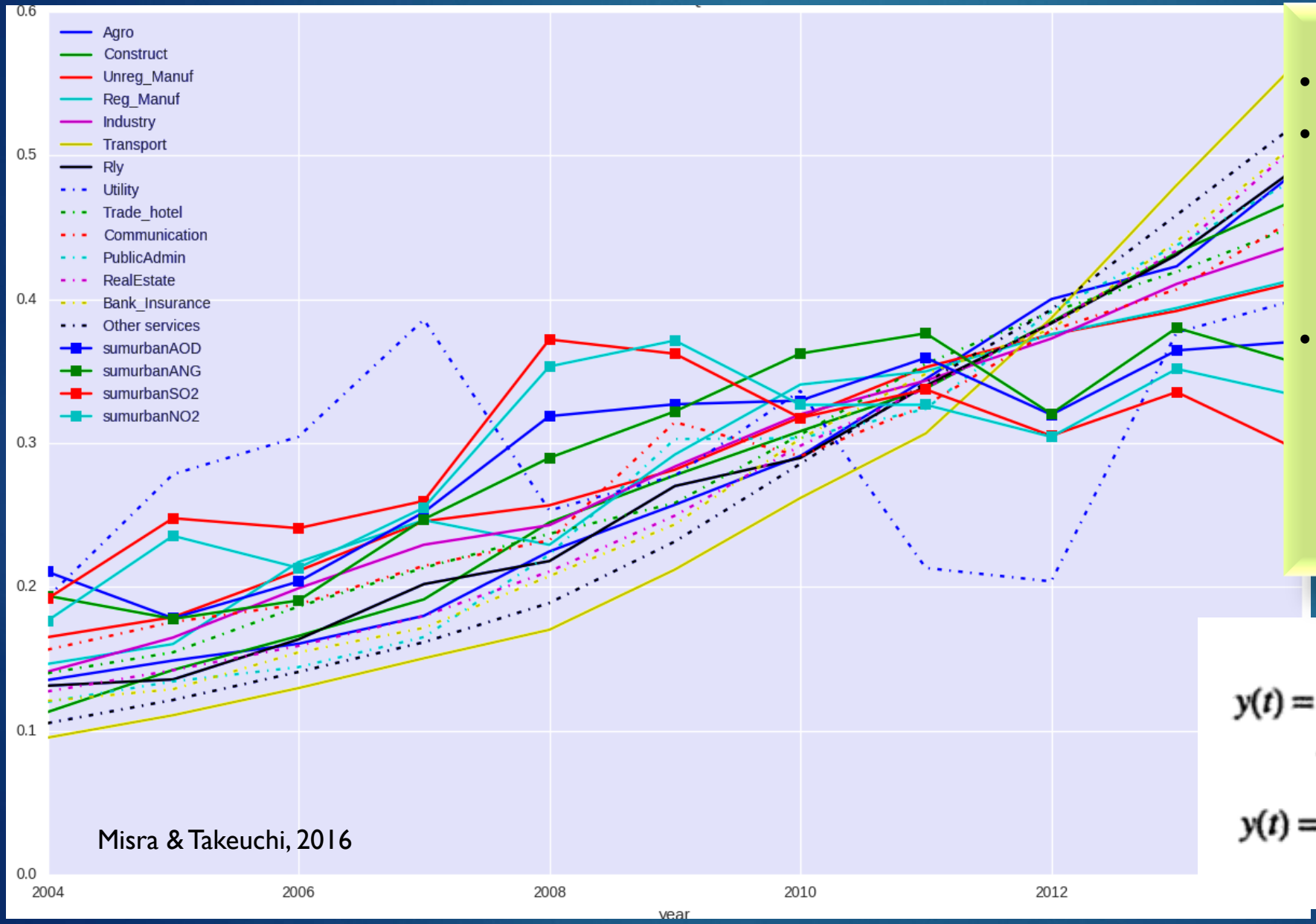
Conclusions

- To manage, measure. Remote sensing datasets.
- Rise in urban air pollution
- Statistically, industries and construction are causes
- Strong correlations with built-up urban area

Next steps:

- Technology dependent emission coefficients
- Use as a policy variable for future emission
- Estimate future scenarios

Correlation and Causality Test



Misra & Takeuchi, 2016

Economic sectors

- **Agriculture** and allied activities
- **Industry**
  - Manufacturing
  - Construction,
  - Public utilities, Others
- **Services**
  - Transport, Railways, Trade and hotels, Banking/Insurance, Communication, Real estate , Public administration

$$y(t) = \sum_{i=1}^{\infty} \alpha_i y(t-i) + c_1 + v_1(t)$$

$$y(t) = \sum_{i=1}^{\infty} \alpha_i y(t-i) + \sum_{j=1}^{\infty} \beta_j x(t-j) + c_2 + v_2(t)$$