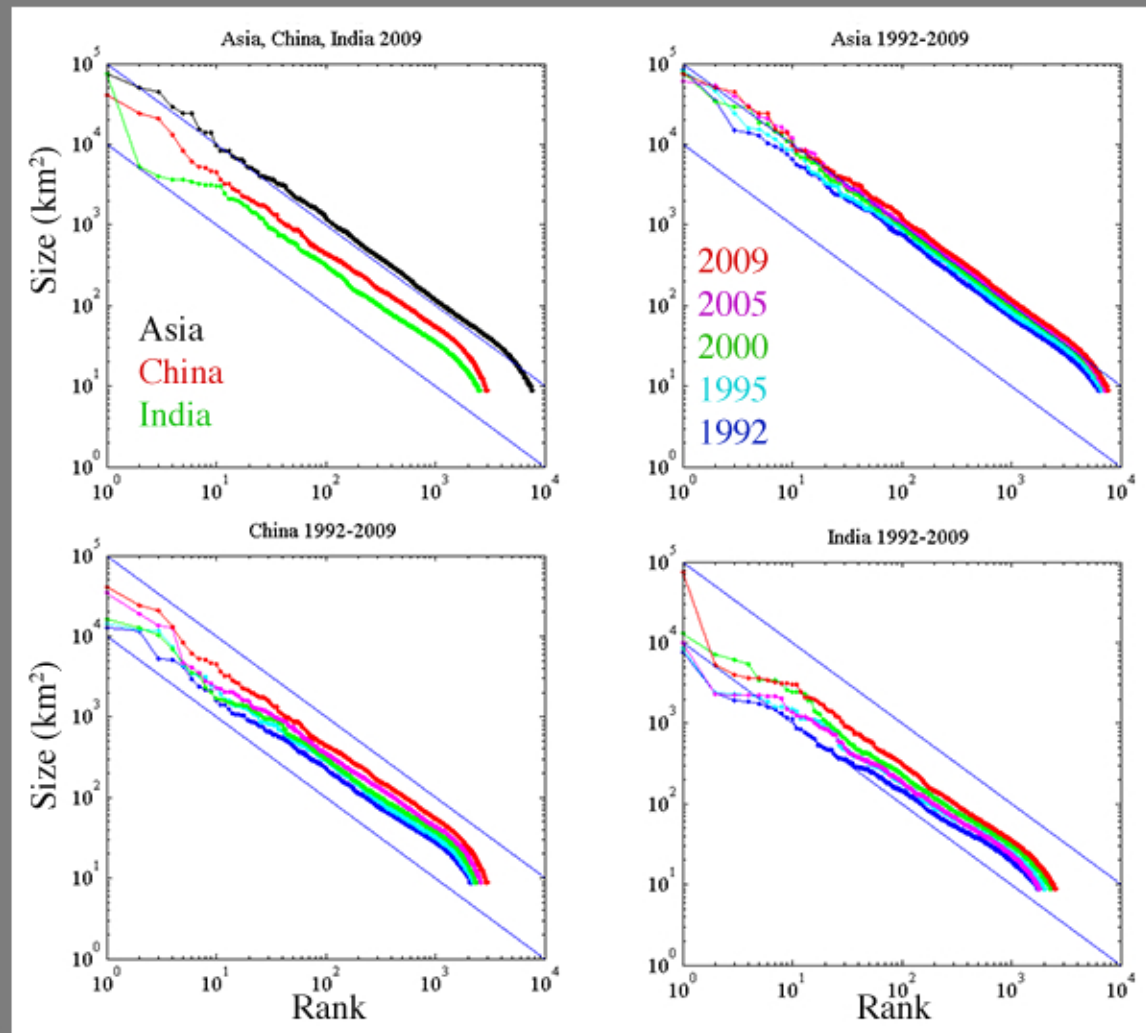


Decadal Change in Asia

Between 1992 and 2009 both China and India maintained apparent power law rank-size distributions of lighted areas while growing - although the slope increases for both with time.



Complementary Scaling of Population and Development

At both global and continental scales both population density and night light intensity scale as power laws

Scaling spans a wide range of density and brightness thresholds.

As threshold decreases, growth of large spatial networks vastly exceeds the size of the largest cities.

At lowest thresholds:

Lights well fit by power law

but

Slope increases abruptly

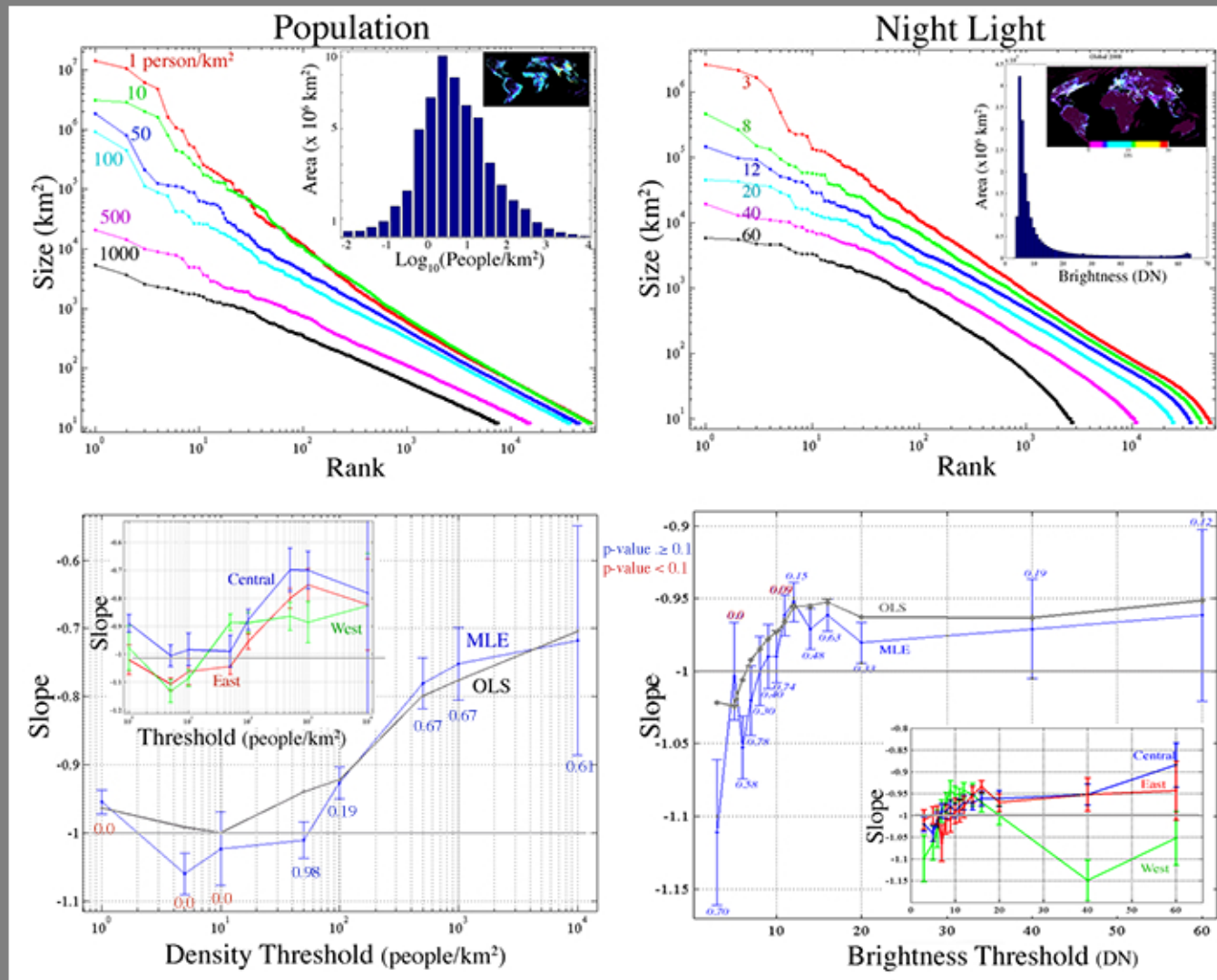
Density well fit at all thresholds

but

Upper tail grows increasingly faster

Both density and brightness grow increasingly spatially connected at lower thresholds - but within limited area.

Both systems experience focused spatial growth analogous to explosive percolation in networks.



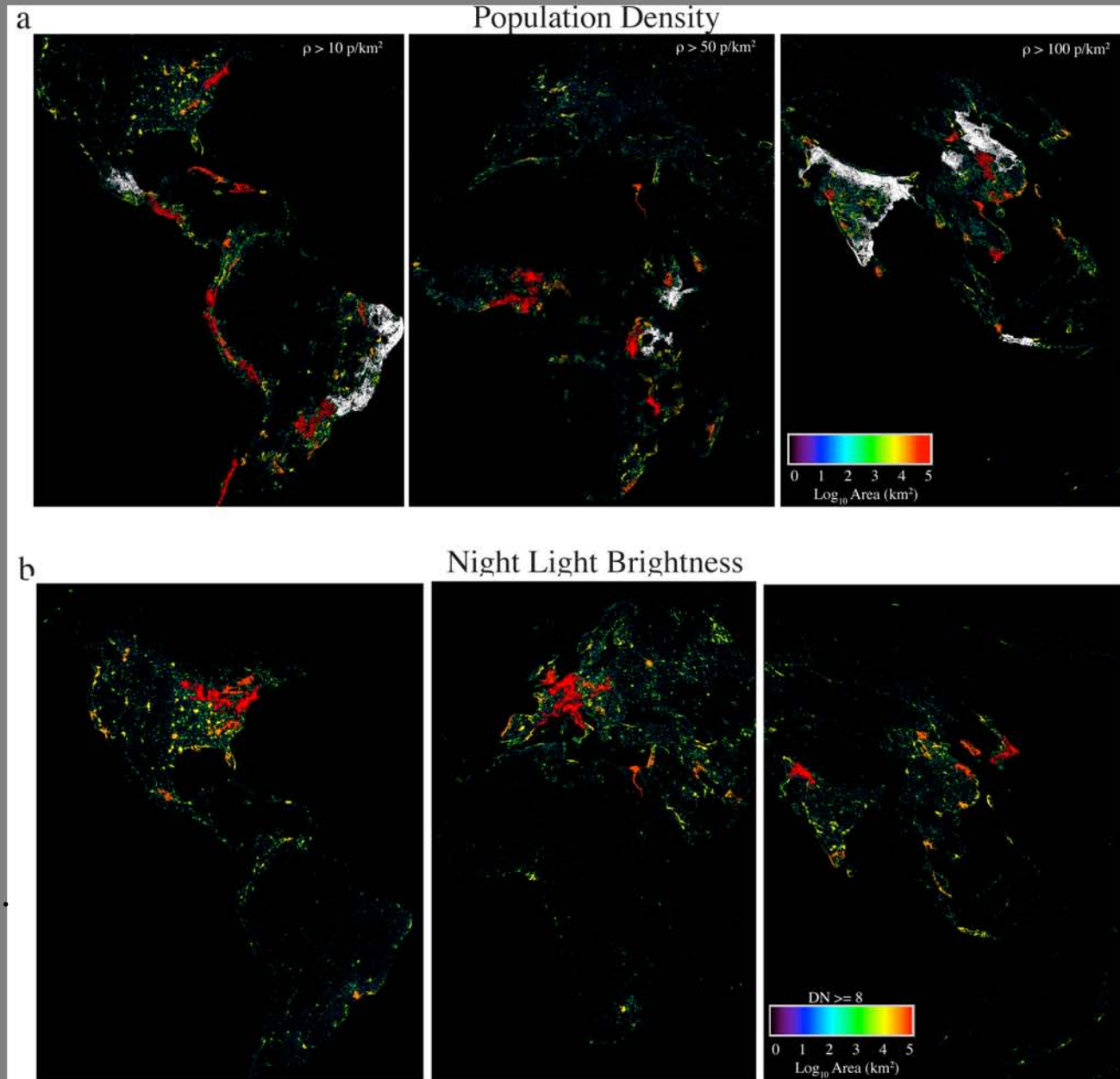
Spatial Networks of Population & Development

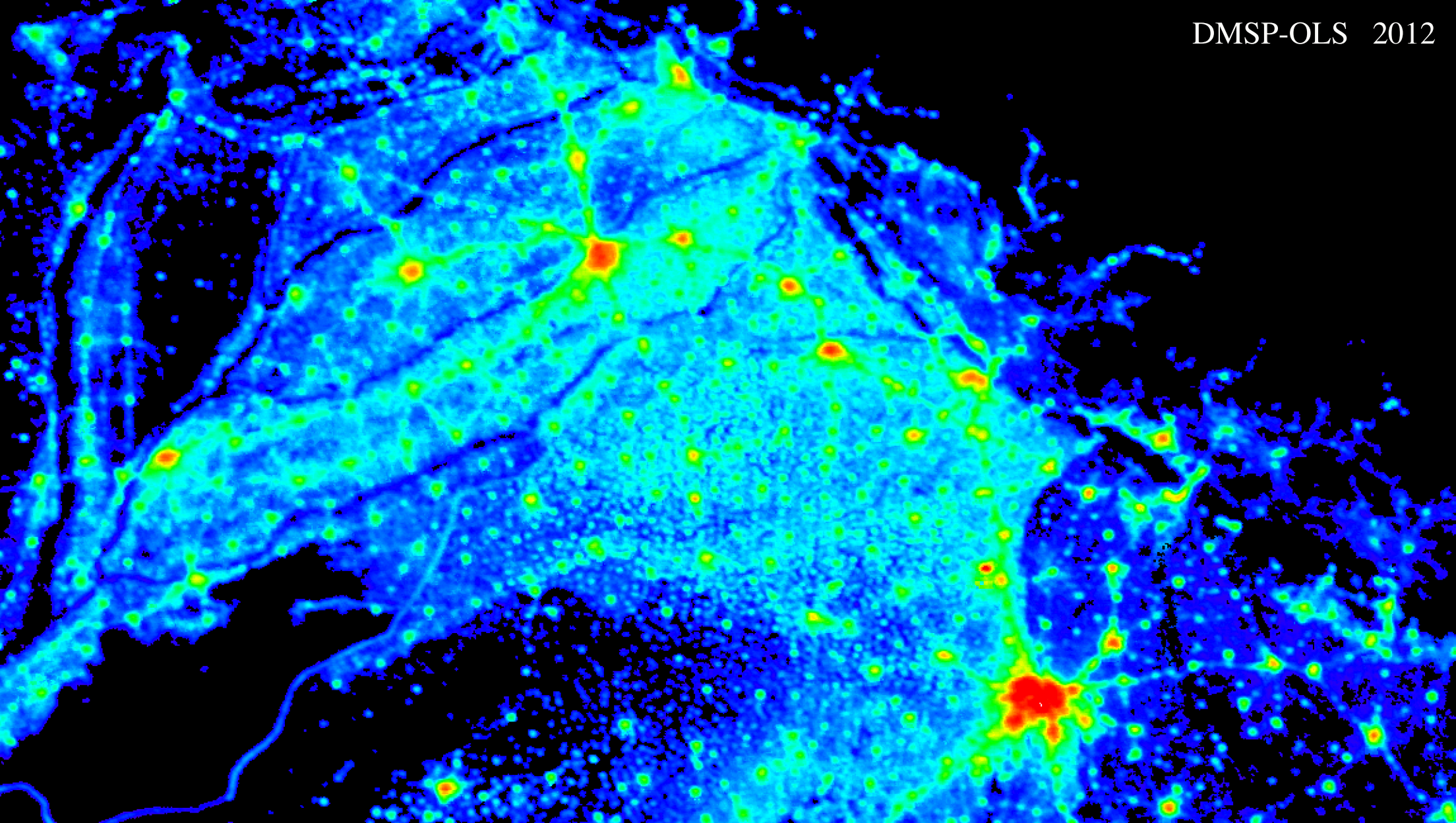
Networks of population density are much larger than networks of night lights.

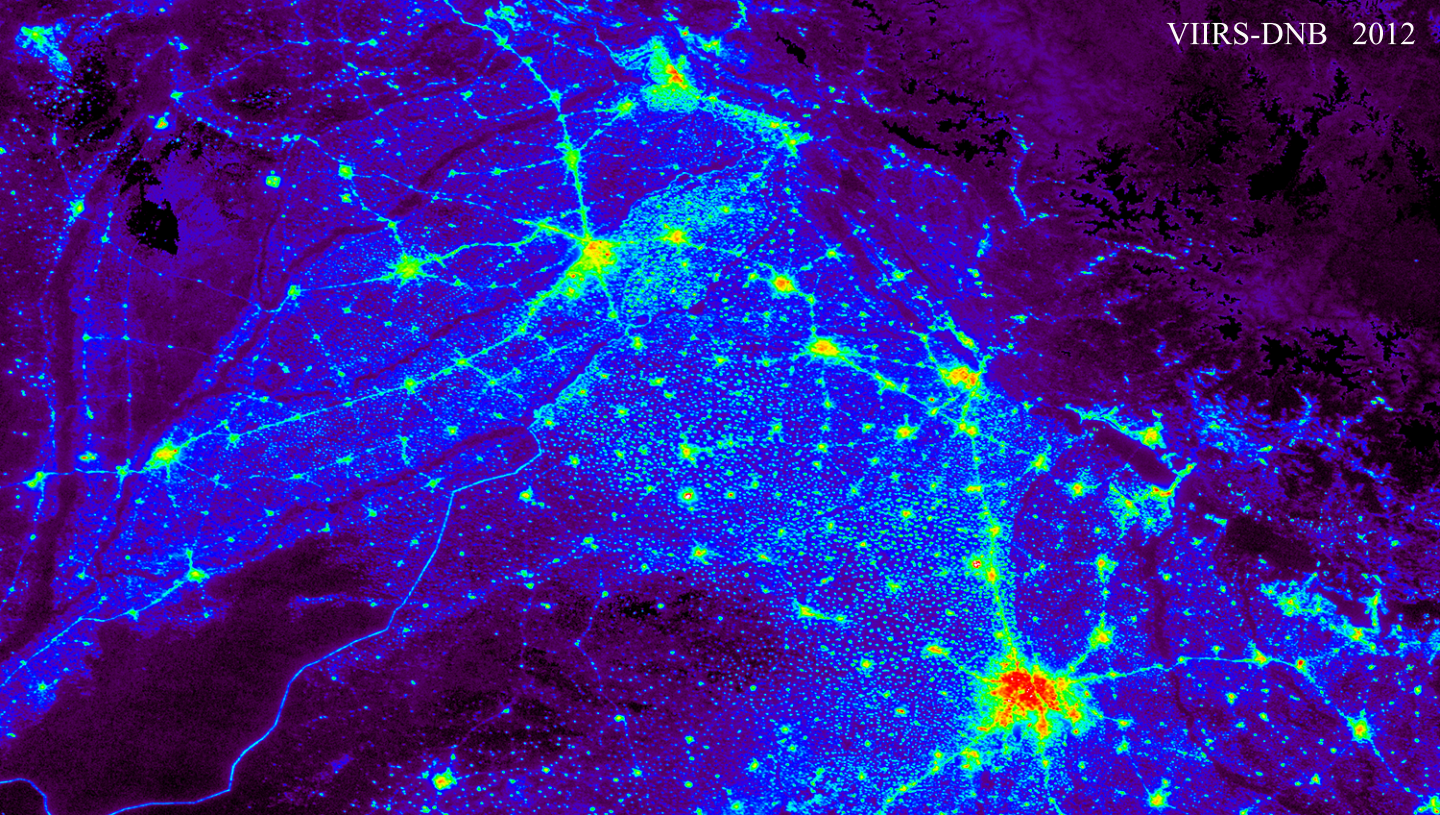
Population and development networks are nearly spatially exclusive geographically:

Largest population density networks in Latin America, SubSaharan Africa, South and East Asia.

Largest night light networks in North America, Central Europe, South Korea, Japan, the Punjab and China's deltas.







Rank-Size Distributions of VIIRS-DNB Night Light

Zipf's Law holds at continental scales

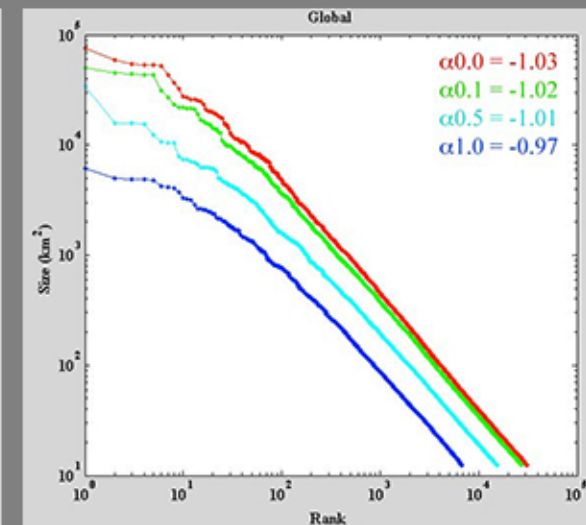
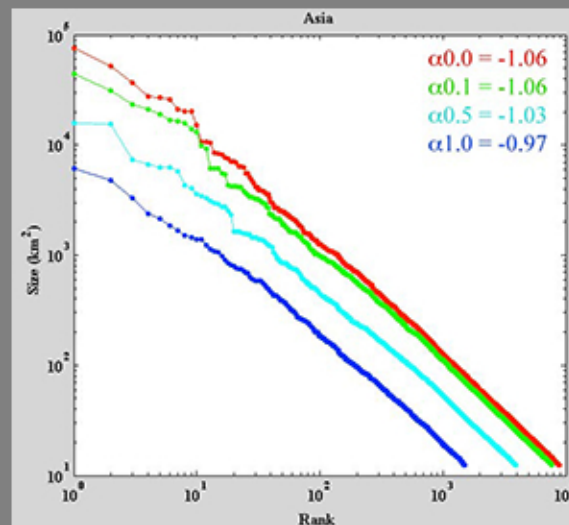
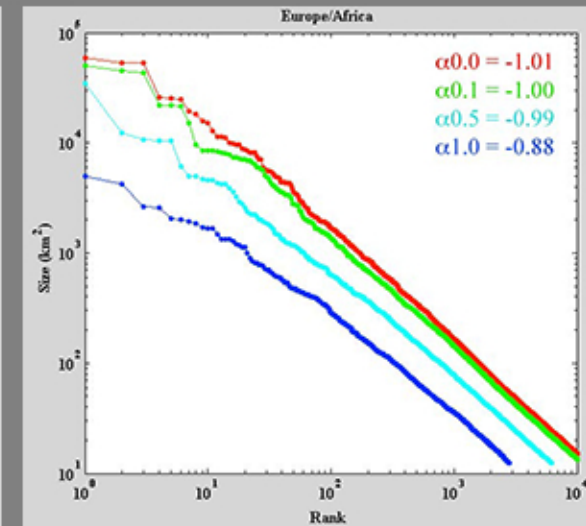
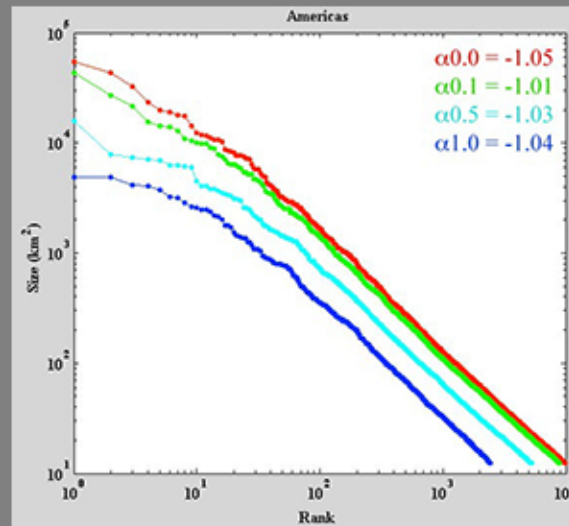
At continental scales, all 3 longitudinal sectors show strong power law scaling with exponents near, but spanning, -1.

Varying degrees of fragmentation of the largest spatial networks.

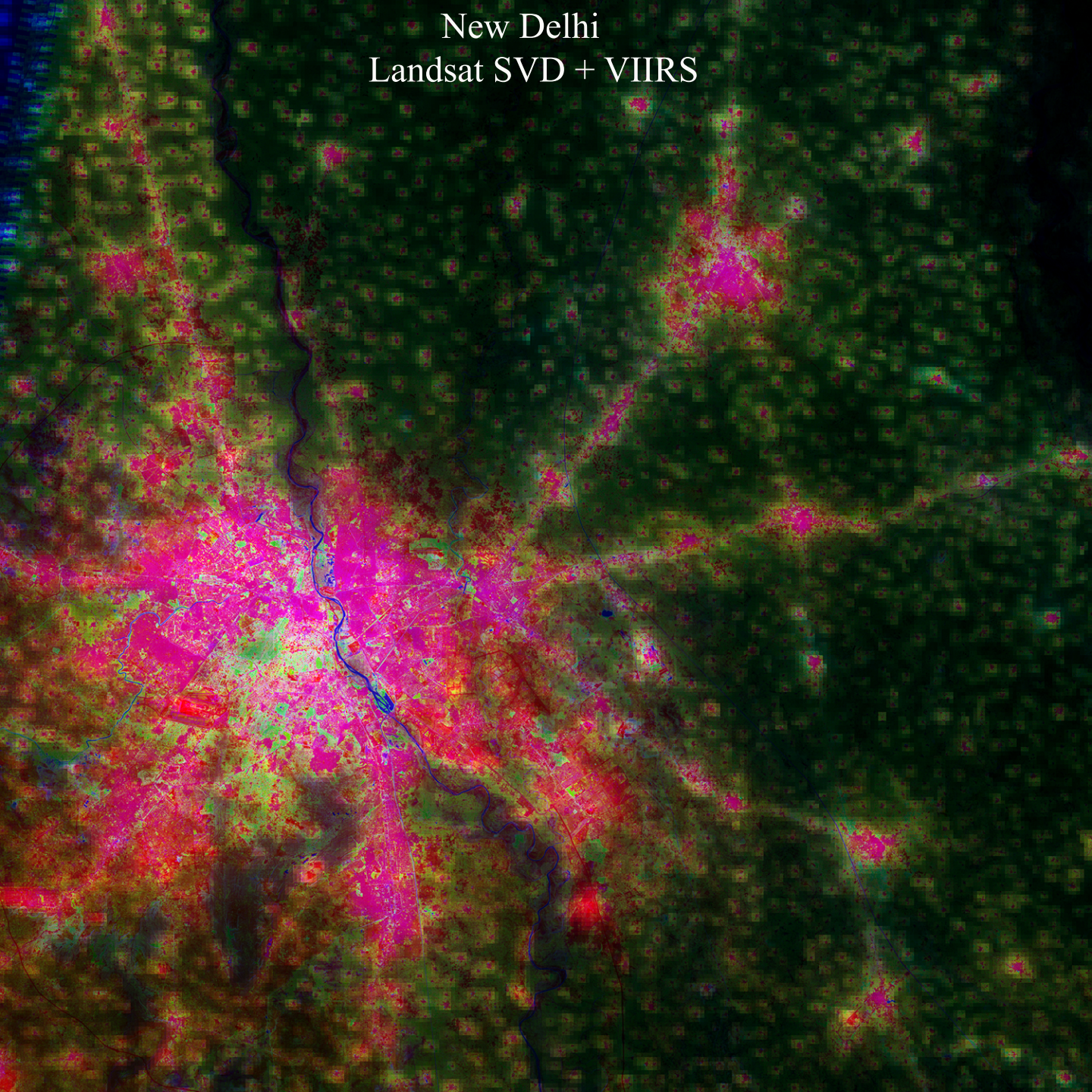
Some roll-off in upper tails

but

No roll-off in lower tails



New Delhi
Landsat SVD + VIIRS



Conclusions & Implications

Multi-threshold, rank-size distributions provide robust parameterizations of systems of settlements and spatial networks of development.

Robust parameterizations provide explicit constraints for hypothesis testing.

Both night light and population density are consistent with power law scaling at continent to global scales - but for different spatial networks of settlements.

Different manifestations of human activity share common structure & process?

Largest spatial agglomerations are much larger ($\sim 10^6$ km²) than individual cities; Spatial networks extend scaling properties from village to continent scale.

Human modification of landscape spatially fractal at continent scale?

Recent economic growth and urban development in China and India post-1992 maintain scaling but with increasing slope as connectivity increases.

Current growth process may differ from proportional growth assumed in past.

