

# Measuring Spatial Inequality

## An International Perspective

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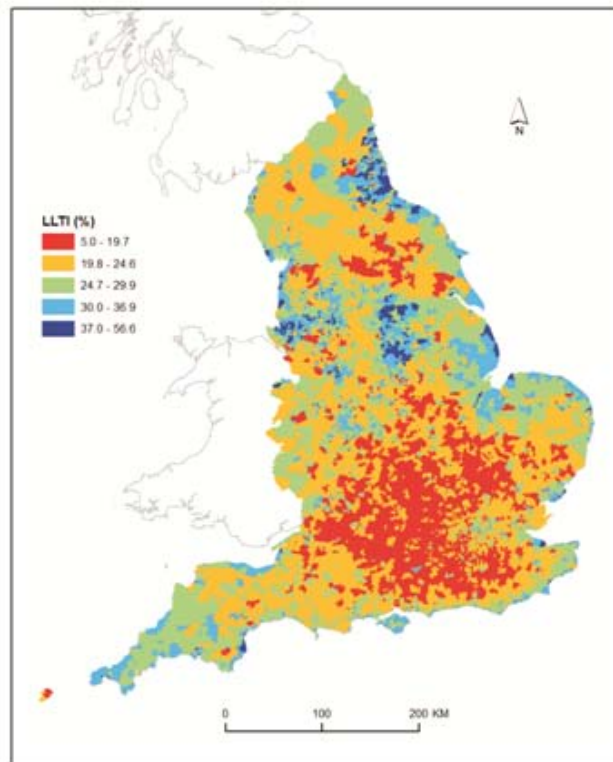
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# Outline

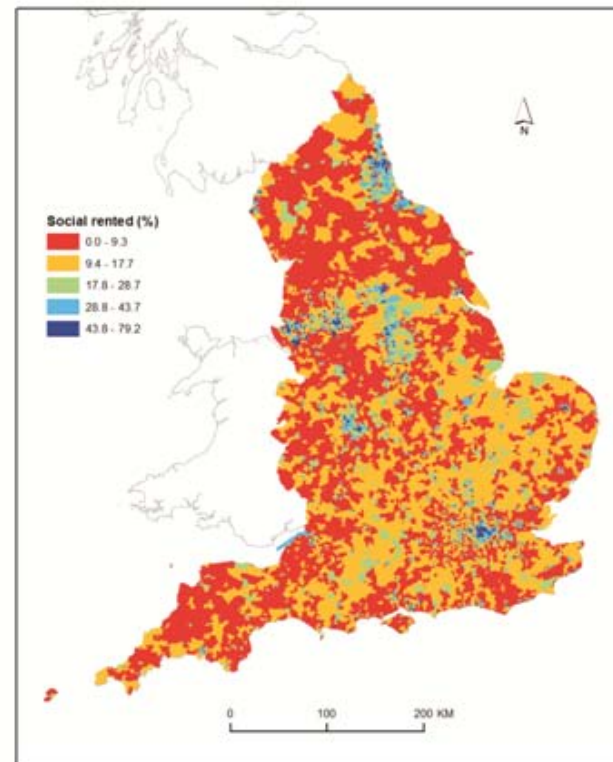
1. Defining spatial structure and spatial inequalities
2. Measuring spatial inequalities in England and Wales analysis: 2001 and 2011
3. Comparative research
  1. England and Wales and the USA
  2. South Africa and England



# Spatial structure: Health (LLTI) and social rented households in 2001, in England by Census wards



(a)



(b)



# Spatial structure and inequalities

- Are inequalities the same across areas?
- How far are population sub-groups geographically:
  - Uneven?
  - Clustered?
- What are the scales of geographical inequalities?
  - Locally clustered?
  - Strong regional trends?



# Spatial structure and inequalities

- Example of Northern Ireland
  - The population is more spatially concentrated by religion than by a host of demographic, social and economic variables
  - But, religious segregation reduced between 1971 and 2011



# Measures of population distribution

## Index of dissimilarity, $D$

Measure of spread of two groups possible values 0-1

0 = the groups are equally spread (e.g., all zones have a 65/35 split of two groups)

1 = the groups are completely uneven (all zones are 100% one group and 0% of the other)

## Moran's $I$ (autocorrelation coefficient)

A measure of the correlation between data values and neighbouring data values (thus, a measure of clustering)

Unlike correlation coefficient, not strictly constrained to -1, 1

Positive values = clustering; negative values = neighbouring values tend to be different

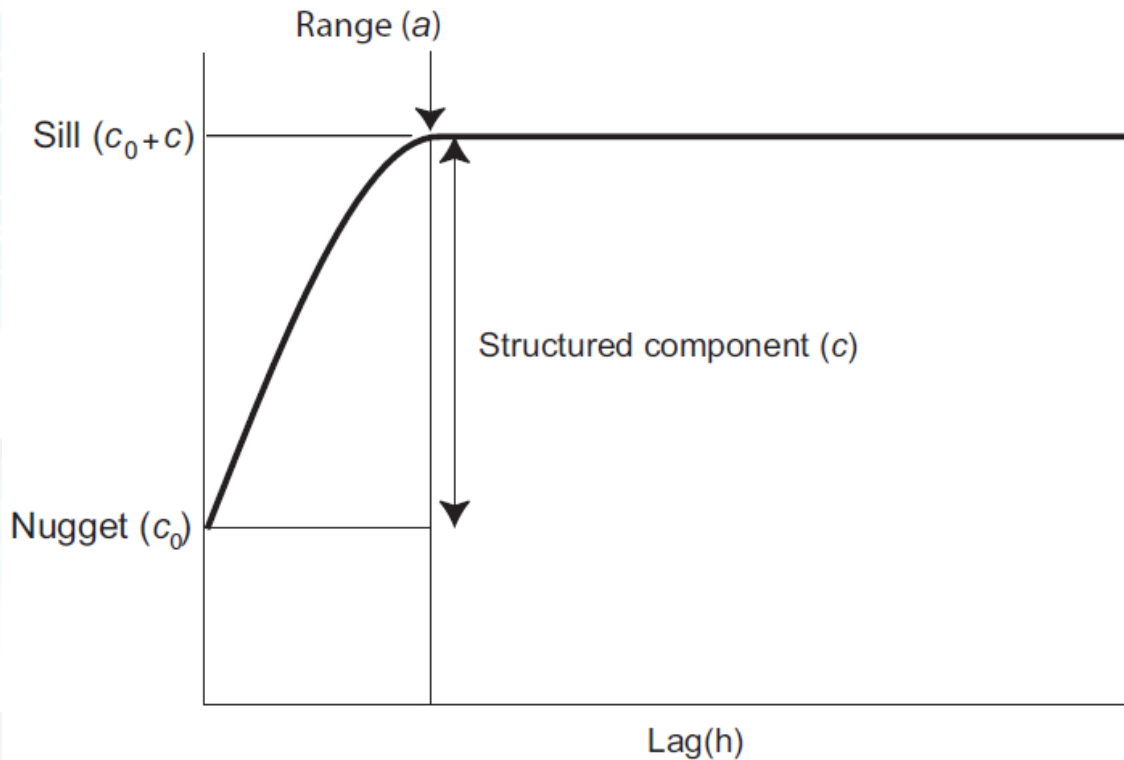
# Measures of population distribution

## Variogram: spatial dependence at different spatial scales

1. Take each data value in turn and compute its squared difference from each of the other values in the data set and store the distances between them
2. Group these differences into distance bins – e.g., all squared differences for pairs separated by 1 to 2 km and compute half of the average of these differences
3. Plot these (half) average differences against distances
4. The plot shows how difference between values changes as a function of distance



# Variogram model

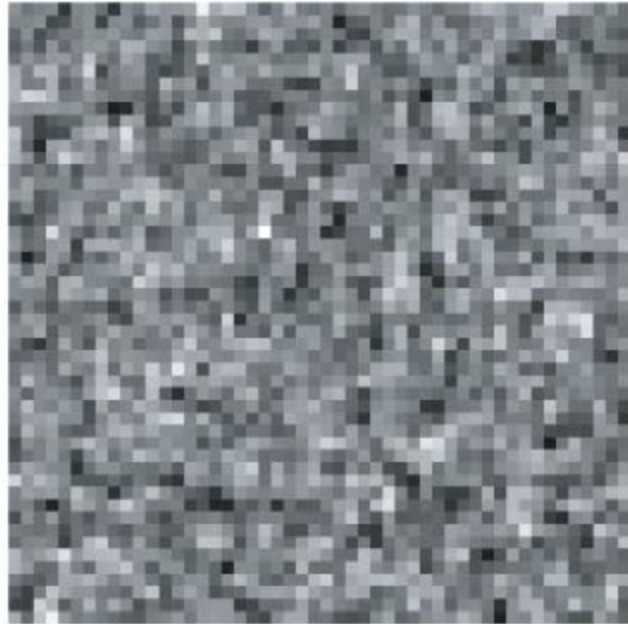


Bounded variogram model: nugget and effect and spherical component.

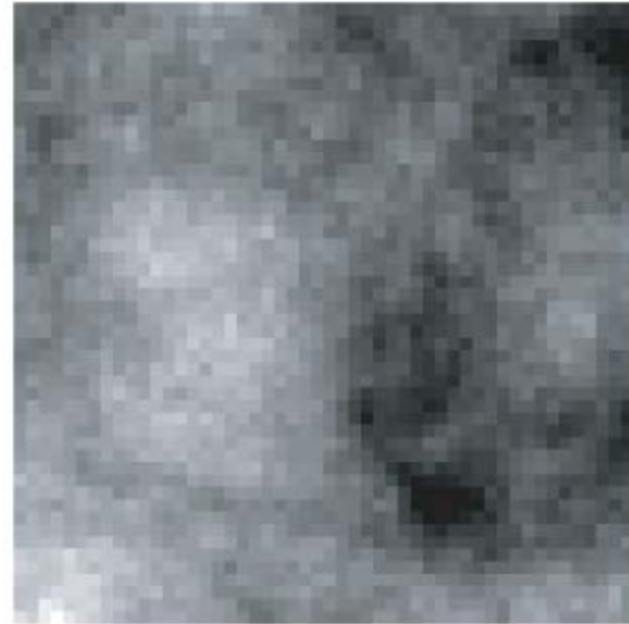
Provides a composite measure of clustering and polarisation: small nugget indicates localised clustering – with a large sill this indicates polarisation



# Variograms



$a = 2$



$a = 40$

Simulated surfaces: spherical model with  $a = 2$  and 40.



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# Spatial Scale and Geographical Inequalities in England and Wales, 2001-2011

Common demographic, social and economic variables derived from the England and Wales Census for 2001 and 2011

Age, Ethnicity, Housing tenure, Car or van access, Qualifications, Employment, National Statistics Socio-economic classification and Health.

**How uneven are population sub-groups in England and Wales?**

**How clustered are these groups and over what spatial scales are they concentrated?**



# Variables

| Variable     | Description                       |
|--------------|-----------------------------------|
| A0to15       | Persons aged 0 to 15 years        |
| A16to29      | Persons aged 16 to 29 years       |
| A30to64      | Persons aged 30 to 64 years       |
| A65plus      | Persons 65 years plus             |
| WhiteNW      | (Non) White persons               |
| OwnOcc       | Owner occupied households         |
| SocRent      | Social rented households          |
| PrivRent     | Private rented households         |
| NoCarsVans   | Households with (no) cars or vans |
| NoQualQual   | Persons with (no) qualifications  |
| EAmployUnemp | (Un)employed persons              |
| NSSEC12      | Persons in NSSEC 1-2              |
| NSSEC37      | Persons in NSSEC 3-7              |
| NSSEC8       | Persons in NSSEC 8                |
| LLTI         | Persons with (no) LLTI            |

Data are of 2001 and 2011 Output Areas  
for England and Wales



# Index of dissimilarity, $D$

| Variable      | 2001  | 2011  | 2011-2001 |
|---------------|-------|-------|-----------|
| A0to15        | 0.159 | 0.161 | 0.002     |
| A16to29       | 0.197 | 0.208 | 0.011     |
| A30to64       | 0.110 | 0.102 | -0.008    |
| A65plus       | 0.258 | 0.274 | 0.016     |
| WhiteNW       | 0.623 | 0.592 | -0.031    |
| OwnOcc        | 0.491 | 0.446 | -0.045    |
| SocRent       | 0.613 | 0.592 | -0.021    |
| PrivRent      | 0.384 | 0.371 | -0.013    |
| NoCarsVans    | 0.391 | 0.402 | 0.011     |
| NoQualQual    | 0.223 | 0.255 | 0.032     |
| EAEmployUnemp | 0.329 | 0.300 | -0.029    |
| NSSEC12       | 0.271 | 0.265 | -0.006    |
| NSSEC37       | 0.239 | 0.207 | -0.032    |
| NSSEC8        | 0.464 | 0.374 | -0.090    |
| LLTI          | 0.197 | 0.199 | 0.002     |

Data: Output  
Areas for England  
and Wales



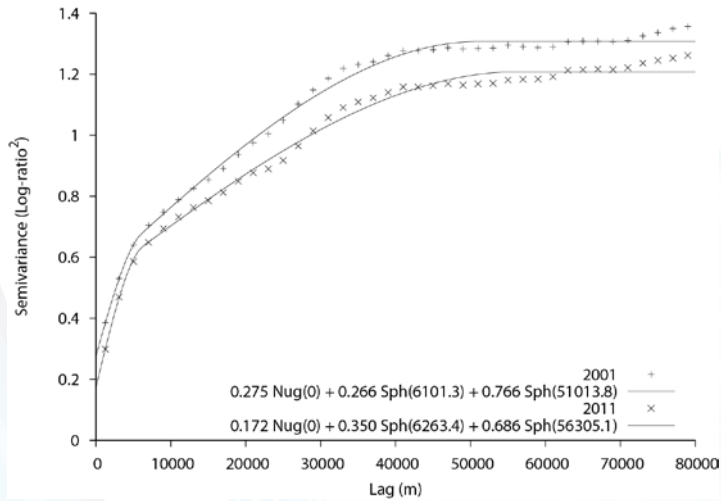
# Moran's I

|             | LA 20 NN | LA 100 NN | LA 20 NN | LA 100 NN | LA 20 NN  | LA 100 NN |
|-------------|----------|-----------|----------|-----------|-----------|-----------|
|             | 2001     | 2001      | 2011     | 2011      | 2011-2001 | 2011-2001 |
| LRage1      | 0.345    | 0.216     | 0.448    | 0.321     | 0.103     | 0.105     |
| LRage2      | 0.395    | 0.278     | 0.440    | 0.321     | 0.045     | 0.043     |
| LRage3      | 0.431    | 0.335     | 0.524    | 0.417     | 0.093     | 0.082     |
| LREthnicity | 0.752    | 0.702     | 0.838    | 0.774     | 0.086     | 0.072     |
| LRTenure1   | 0.388    | 0.255     | 0.400    | 0.248     | 0.012     | -0.007    |
| LRTenure2   | 0.475    | 0.360     | 0.577    | 0.455     | 0.102     | 0.095     |
| LRCarsVans  | 0.584    | 0.448     | 0.645    | 0.515     | 0.061     | 0.067     |
| LRQual      | 0.598    | 0.468     | 0.564    | 0.437     | -0.034    | -0.031    |
| LREmploy    | 0.445    | 0.359     | 0.475    | 0.367     | 0.030     | 0.008     |
| LRNSSEC1    | 0.481    | 0.387     | 0.591    | 0.473     | 0.110     | 0.086     |
| LRNSSEC2    | 0.664    | 0.530     | 0.697    | 0.561     | 0.033     | 0.031     |
| LLTI        | 0.397    | 0.297     | 0.411    | 0.307     | 0.014     | 0.01      |

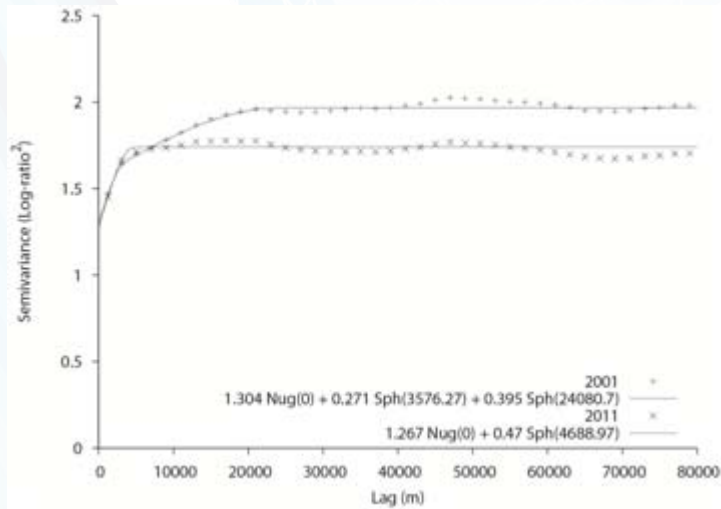
Data: Output Areas for England and Wales  
 NN is nearest neighbours



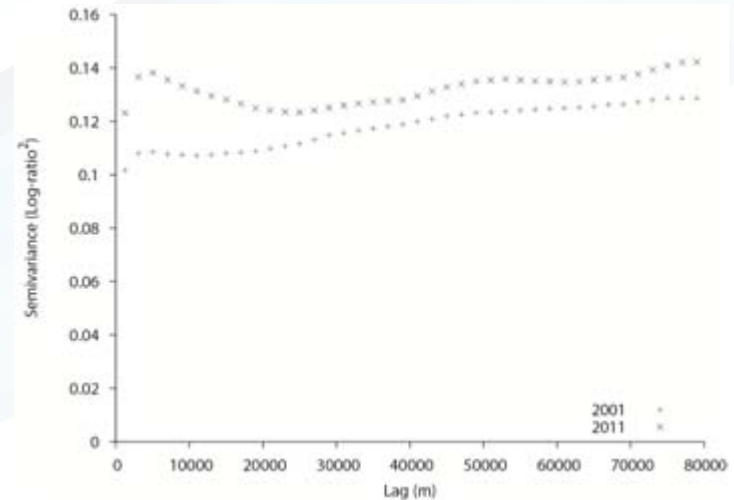
# Variograms



*White/non White*: Clustering over small areas increased between 2001 and 2011, variance decreased – strong spatial structure, but regions are becoming more similar (consistent with standard deviation)



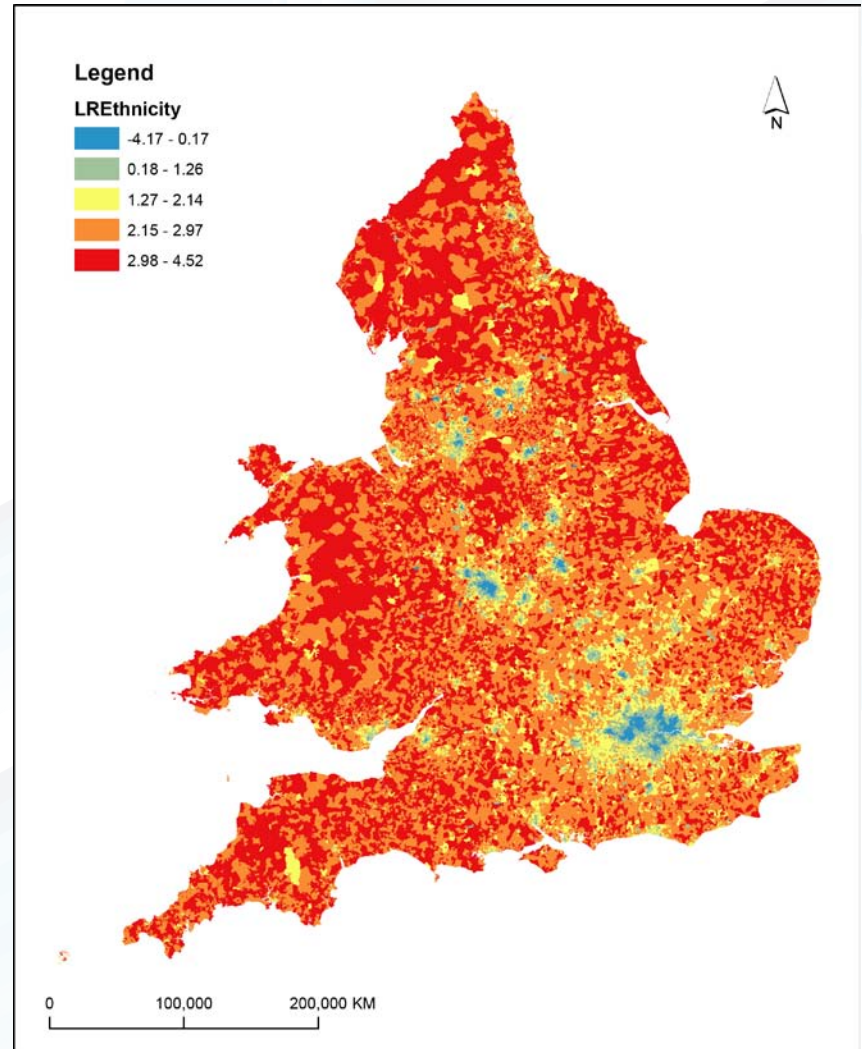
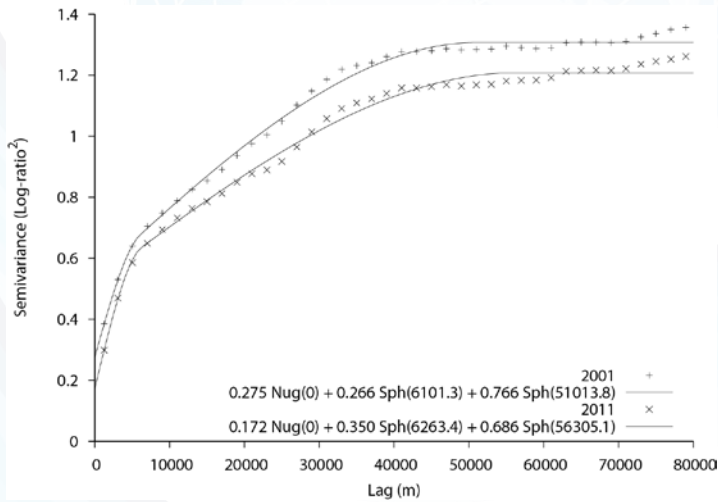
*Owner occupied and Private rented HH / Social rented HH*: Clustering over small areas increased between 2001 and 2011, but variance decreased; much less spatial structure than for White/non White



*LLTI*: Clustering over small areas, but no evidence of spatial structure; variance increased – regions are becoming more dissimilar



# White/Non White



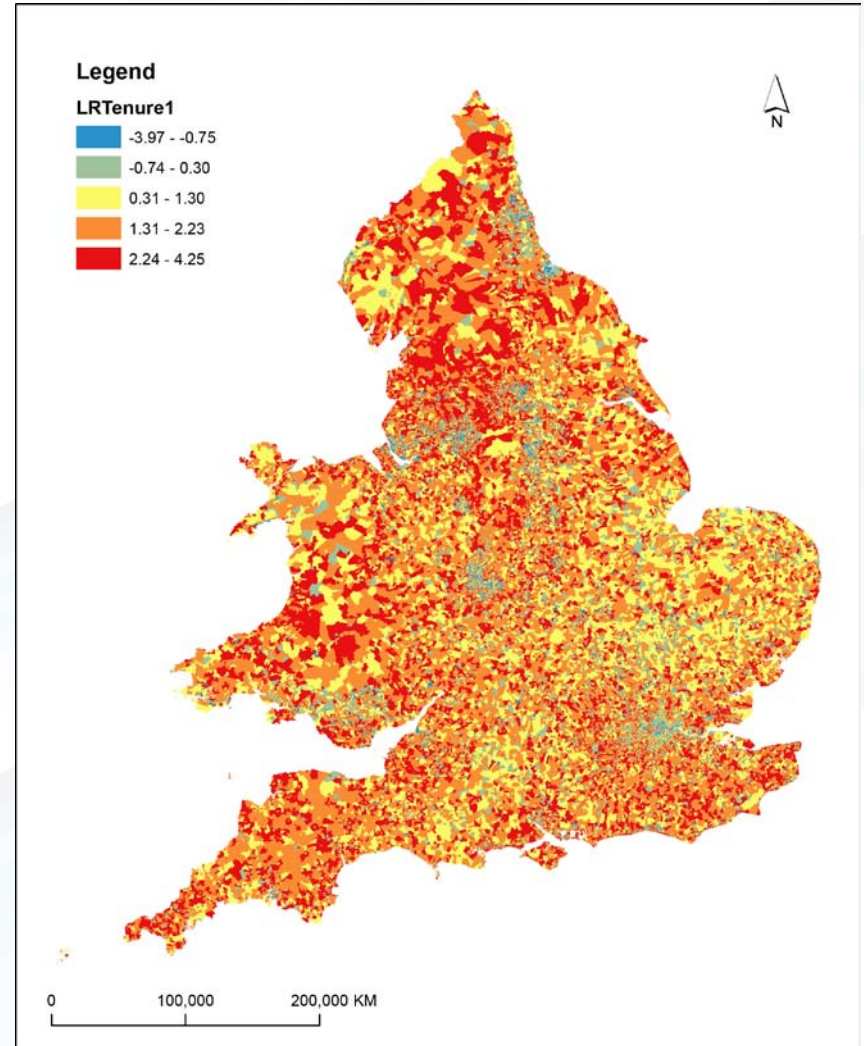
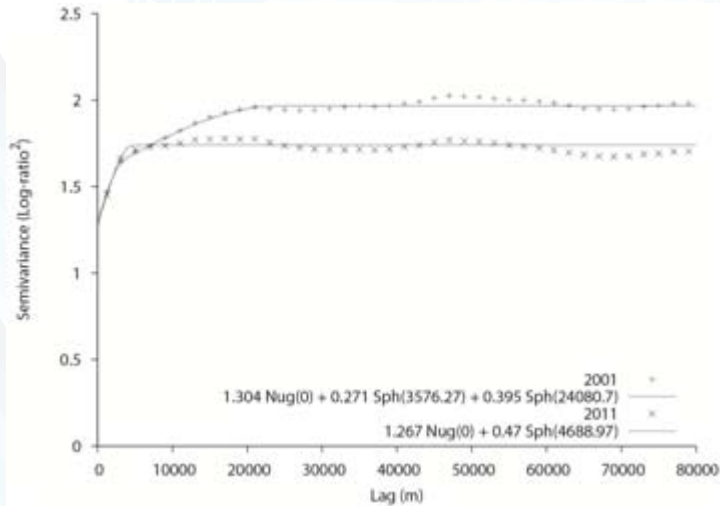
2011 OAs



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# Owner occupied HH and Private rented / Social rented HH



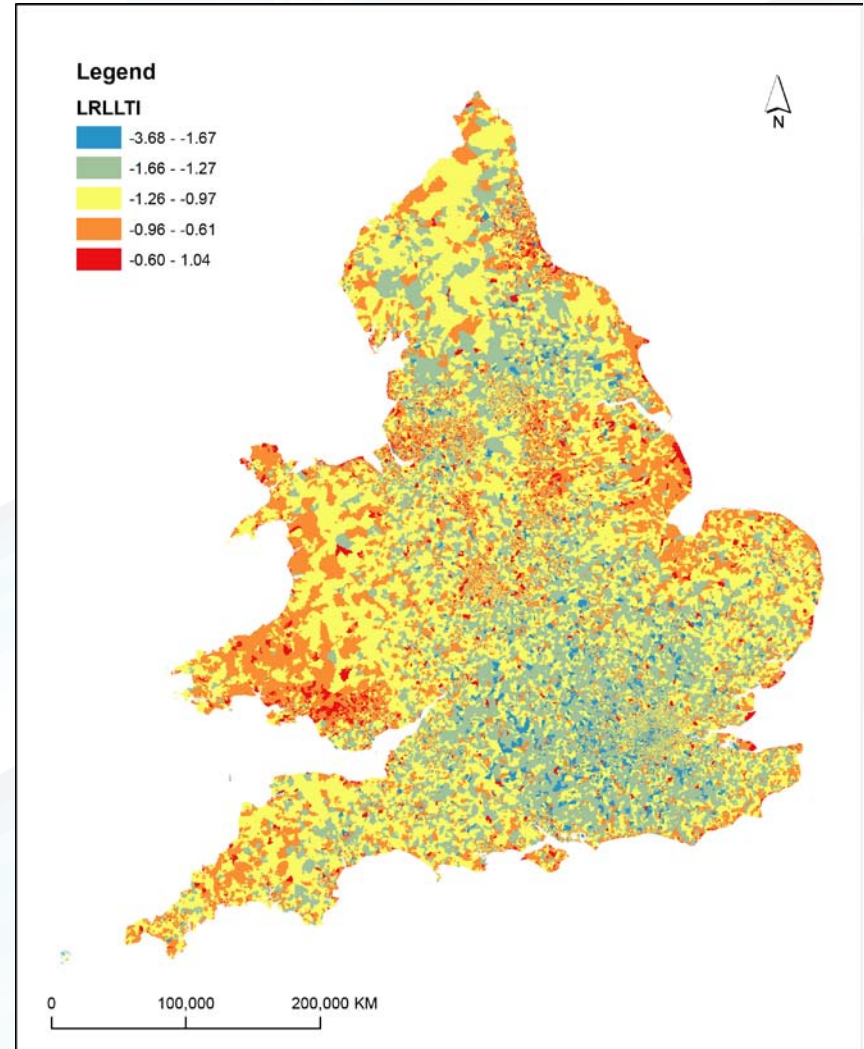
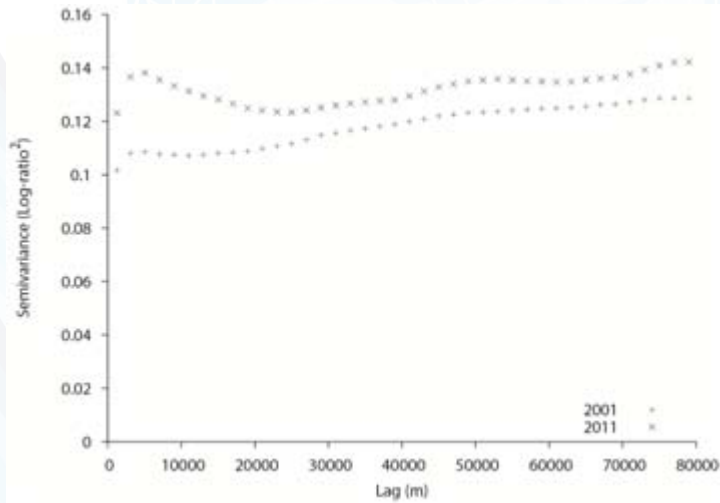
2011 OAs



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# LLTI/Non LLTI



2011 OAs



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# Findings summary

| Rank | I: 2001     | I: 2011     | SD: 2001    | SD: 2011    |
|------|-------------|-------------|-------------|-------------|
| 1    | LREthnicity | LREthnicity | LRTenure1   | LRTenure1   |
| 2    | LRNSSEC2    | LRNSSEC2    | LREthnicity | LREthnicity |
| 3    | LRQual      | LRCarsVans  | LRNSSEC1    | LRCarsVans  |
| 4    | LRCarsVans  | LRNSSEC1    | LRTenure2   | LRNSSEC1    |
| 5    | LRNSSEC1    | LRTenure2   | LRCarsVans  | LRTenure2   |
| 6    | LRTenure2   | LRQual      | LRage1      | LRage1      |
| 7    | LREmploy    | LRage3      | LREmploy    | LREmploy    |
| 8    | LRage3      | LREmploy    | LRNSSEC2    | LRQual      |
| 9    | LRLlTI      | LRage1      | LRQual      | LRNSSEC2    |
| 10   | LRage2      | LRage2      | LRage3      | LRage3      |
| 11   | LRTenure1   | LRLlTI      | LRLlTI      | LRLlTI      |
| 12   | LRage1      | LRTenure1   | LRage2      | LRage2      |

Log-ratios ranked from largest (Rank 1) to smallest (12) for values of Moran's I (20 nearest neighbours) and standard deviation (SD)



# Findings

- The age variables tend to be **less uneven** and **less clustered** than the other variables
- Small levels of clustering reflect, in some cases, high levels of clustering in some areas, but high variability elsewhere – social housing is a key example
- Between 2001 and 2011 **unevenness** in most population sub groups in England and Wales **reduced**
- Over the same period, there was an **increase in localised clustering** in the population by most of the demographic and socioeconomic variables assessed
- Taken together, the findings suggest that **local areas have become more similar** but, for many variables, this is against a background of **reduced regional variation**
- In simple terms, there is **increased clustering *within* regions** but **decreased difference *between* regions** for many population variables



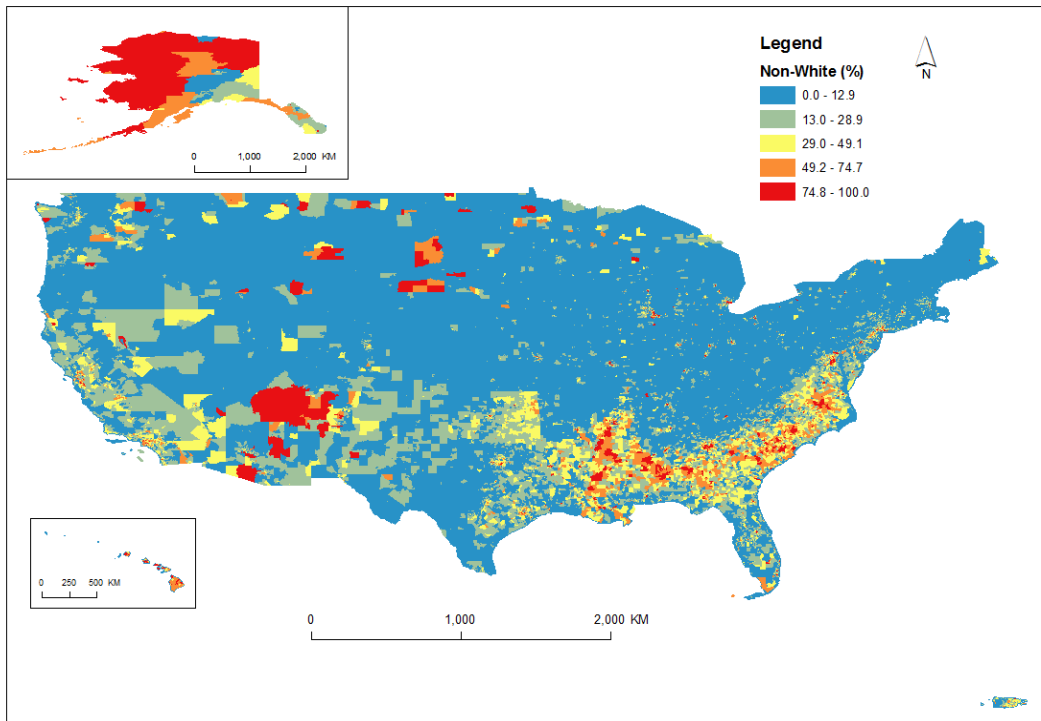
# England and Wales and USA comparison: unevenness

Common demographic, social and economic variables derived from the England and Wales Census for 2011 and the 2012 American Community Survey:

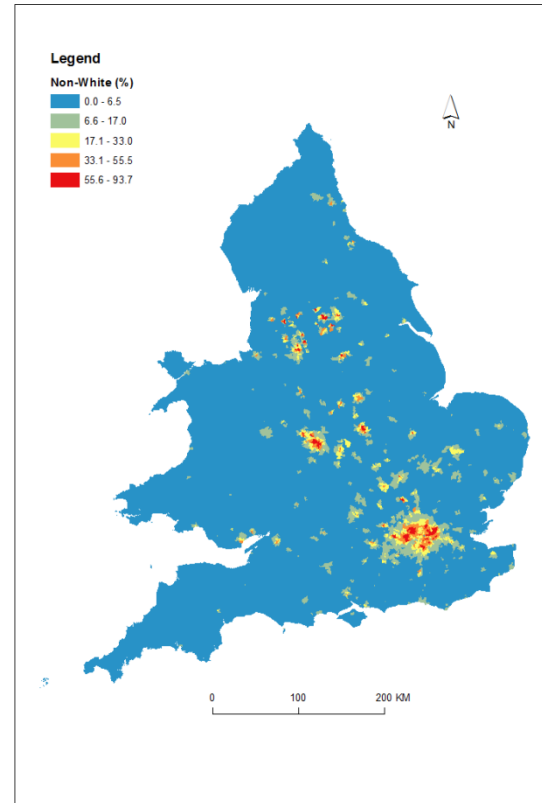
Age, Ethnicity, Housing tenure, Vehicle use, Qualifications, Employment and Health.

**Given broadly comparable variables and zonal systems, how uneven are population sub-groups in England and Wales and in the USA?**



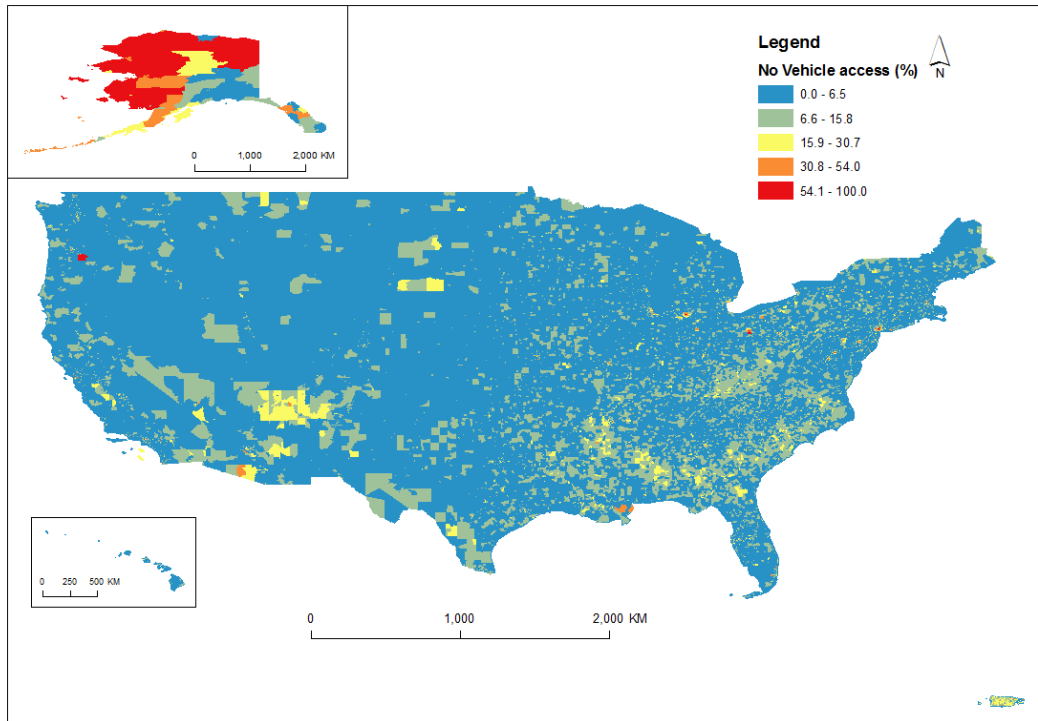


USA: percentage of non-White persons by Census tract, 2012 ACS.

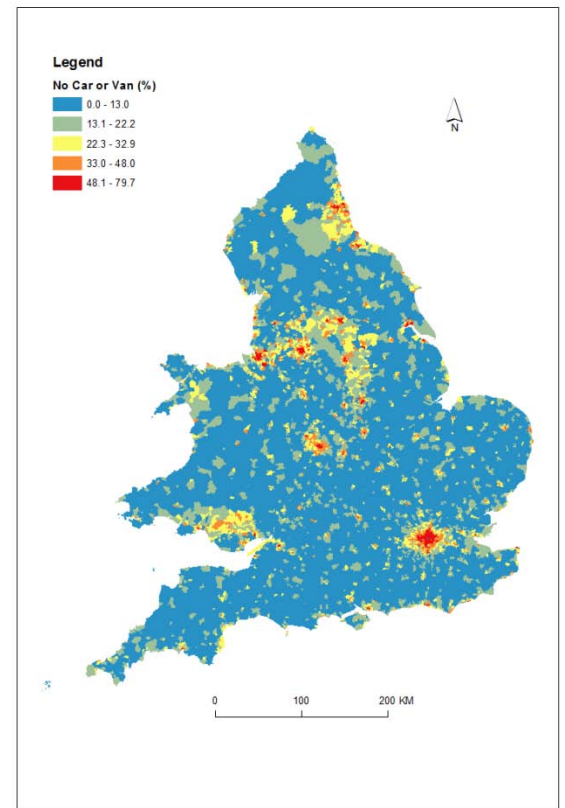


England and Wales: percentage of non-White persons by ward, 2011 Census.





USA: percentage of households with no vehicle access by Census tract, 2012 ACS.



England and Wales: percentage of households with no car or van by ward, 2011 Census.



|                | <b>USA</b>    | <b>E&amp;W</b> | <b>E&amp;W</b> |
|----------------|---------------|----------------|----------------|
|                | <b>Tracts</b> | <b>LSOAs</b>   | <b>Wards</b>   |
| <i>N</i> zones | 74,001        | 34,753         | 8,546          |
| Mean pop       | 4,228         | 1,614          | 6,562          |

**Variable (vs rest) *D***

|            |       |       |       |
|------------|-------|-------|-------|
| A0to17     | 0.138 | 0.117 | 0.087 |
| A18to29    | 0.197 | 0.202 | 0.180 |
| A30to64    | 0.097 | 0.075 | 0.058 |
| A65plus    | 0.214 | 0.209 | 0.169 |
| White      | 0.493 | 0.576 | 0.561 |
| OwnOcc     | 0.393 | 0.370 | 0.289 |
| NoVehicle  | 0.455 | 0.357 | 0.308 |
| NoQual     | 0.287 | 0.212 | 0.178 |
| UnEmployed | 0.233 | 0.252 | 0.212 |
| Health     | 0.201 | 0.150 | 0.122 |

*D* for USA tracts and England and Wales  
(E&W) lower super output areas and wards.



| USA    | E&W   | E&W   |
|--------|-------|-------|
| Tracts | LSOAs | Wards |

**Variable (vs rest)  $D$**

|            |       |       |       |
|------------|-------|-------|-------|
| A0to17     | 0.055 | 0.026 | 0.027 |
| A18to29    | 0.058 | 0.066 | 0.078 |
| A30to64    | 0.028 | 0.021 | 0.019 |
| A65plus    | 0.065 | 0.110 | 0.113 |
| White      | 0.248 | 0.318 | 0.367 |
| OwnOcc     | 0.248 | 0.167 | 0.177 |
| NoVehicle  | 0.467 | 0.184 | 0.207 |
| NoQual     | 0.122 | 0.129 | 0.125 |
| UnEmployed | 0.081 | 0.071 | 0.083 |
| Health     | 0.082 | 0.096 | 0.099 |

Spatial  $D$  (1km Gaussian bandwidth) for USA tracts and England and Wales (E&W) lower super output areas and wards.



# South Africa and England comparison: clustering and spatial scale

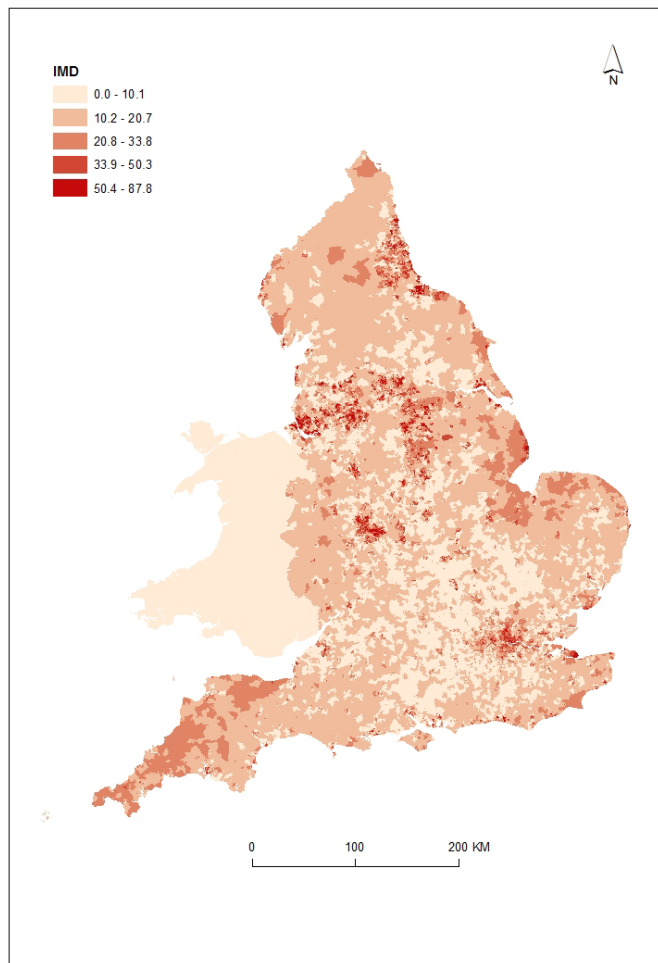
Index of multiple deprivation for South Africa (data zones;  $n = 22846$ ; for 2001) and England (middle super output areas ;  $n = 32482$ ; for 2010)

**How clustered is the IMD in South Africa and in England?**

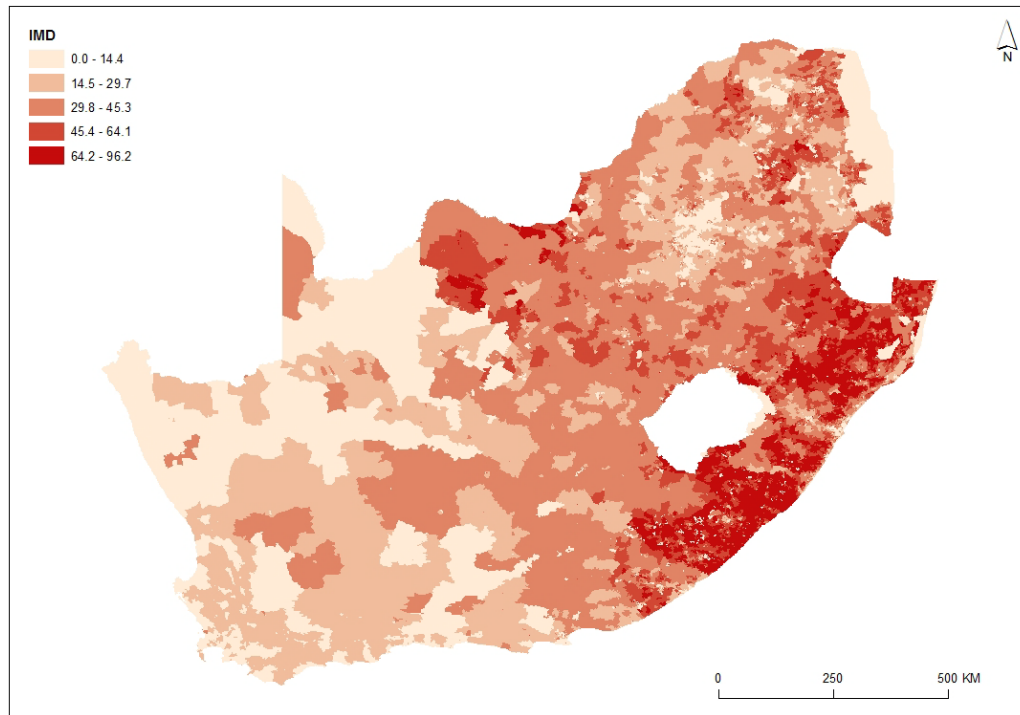
**What are the dominant spatial scales of inequality in South Africa and in England?**



## IMD scores



2010



2001



## IMD scores: Moran's $I$ statistic (clustering)

England MSOAs: 32482  
 South Africa Data Zones: 22846

| Moran's $I$  | 10    | 50    | 100   | 500   | 1000  | 2500  |
|--------------|-------|-------|-------|-------|-------|-------|
| England      | 0.640 | 0.49  | 0.417 | 0.266 | 0.216 | 0.152 |
| South Africa | 0.711 | 0.635 | 0.594 | 0.495 | 0.456 | 0.394 |

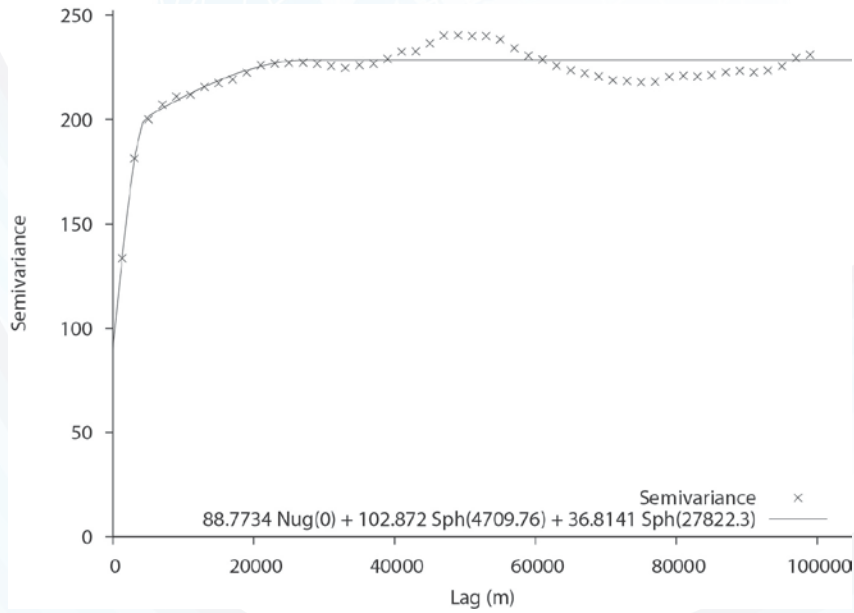
### ***Percentage of zones***

| Percentage       | 0.25 | 0.5 | 1   | 2   | 5    | 10   |
|------------------|------|-----|-----|-----|------|------|
| England $n$      | 81   | 162 | 325 | 650 | 1624 | 3248 |
| South Africa $n$ | 57   | 114 | 228 | 457 | 1142 | 2285 |

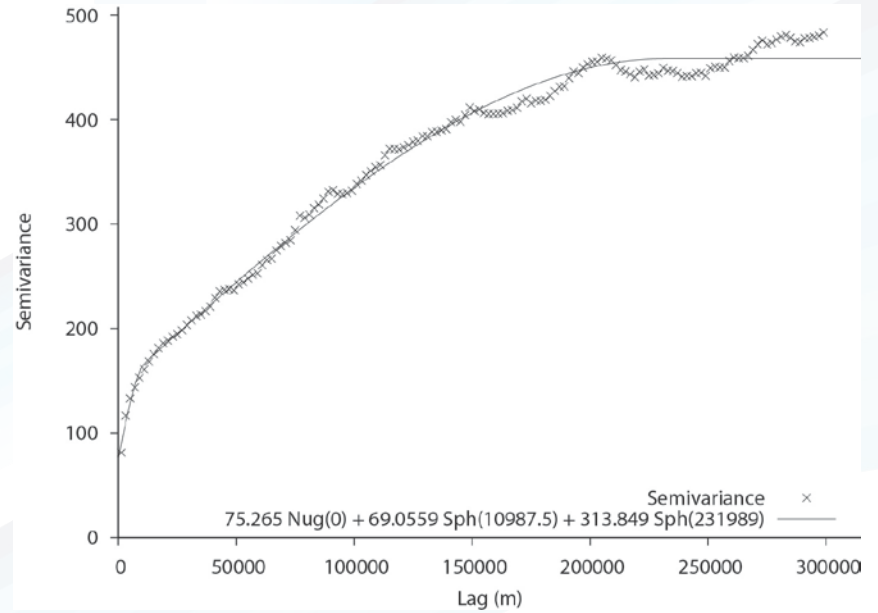
| Moran's $I$  | 0.25  | 0.5   | 1     | 2     | 5     | 10    |
|--------------|-------|-------|-------|-------|-------|-------|
| England      | 0.439 | 0.365 | 0.299 | 0.247 | 0.182 | 0.135 |
| South Africa | 0.627 | 0.586 | 0.544 | 0.500 | 0.449 | 0.402 |



# IMD scores



England



South Africa



# Summary

International comparative studies provide a means of assessing common or contrasting experiences of geographic inequalities and the ways in which they are changing.

An understanding of the spatial distribution of inequalities, as well as the magnitude of inequalities, is important.

Scale is crucial to an understanding of geographic inequalities.



# Acknowledgements

The Office for National Statistics are thanked for provision of the England and Wales data for 2001 and 2011.

Office for National Statistics, 2001 Census: Digitised Boundary Data (England and Wales) [computer file]. ESRC/JISC Census Programme, Census Geography Data Unit (UKBORDERS), EDINA (University of Edinburgh)/Census Dissemination Unit. Census output is Crown copyright and is reproduced with the permission of the Controller of HMSO and the Queen's Printer for Scotland.

Michael Noble is thanked for the provision of the South Africa IMD data.

