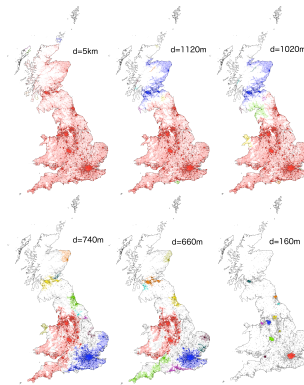


## Urban hierarchies through percolation theory

Elsa Arcaute<sup>1</sup>, Carlos Molinero<sup>1</sup>, Erez Hatna<sup>2,1</sup>, Roberto Murcia<sup>1</sup>, Camilo Vargas-Ruiz<sup>1</sup>, Paolo Masucci<sup>1</sup>, Michael Batty<sup>1</sup>

(1) Centre for Advanced Spatial Analysis, University College London, UK.  
(2) Center for Advanced Modeling, The Johns Hopkins University, USA  
(e-mail: e.arcaute@ucl.ac.uk)

In this talk we present the results [1] of applying percolation theory on the street intersections and on the road network of Britain, to uncover the hierarchical structure of the urban system. We show that through a thresholding procedure [2] a multiplicity of percolation transitions are observed at points where the island gets fragmented into regions can be identified, as shown in the figure. Going down the geographical scale, cities do not emerge as the result of a phase transition. These are recovered by analysing the fractal properties of the emergent clusters. We show that the fractal dimension has a maximum at a distance threshold  $d_c$ . The boundaries of the cities defined at  $d_c$  are in excellent correspondence to the morphological definition of cities given by satellite images, and by other methods previously developed by the authors [3].



[1] E. Arcaute et al. *arXiv:1504.08318 [physics.soc-ph]* (2015).

[2] L.K. Gallos et al. *PNAS*, 109(8):2825–2830 (2012).

[3] E. Arcaute et al. *J. R. Soc. Interface* (2015).