

Supplementary material

Evolution of clustering quantified by a stochastic method – case studies on natural and human social structures

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1. Evolution of universe

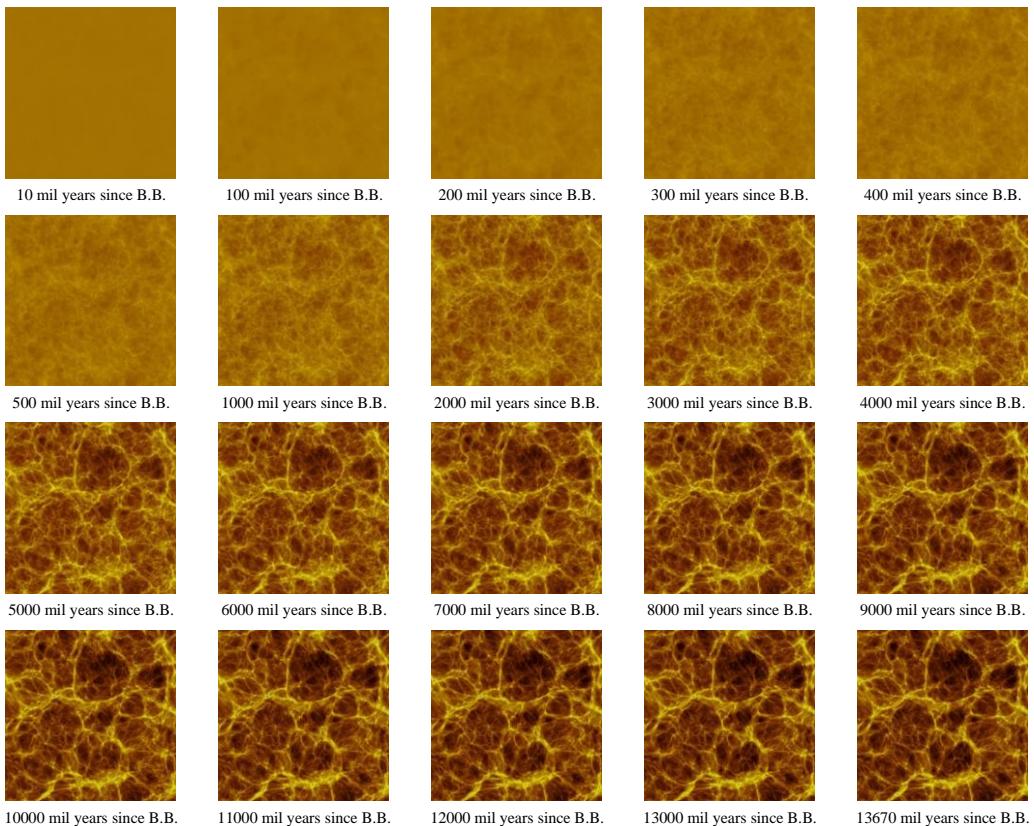


Figure S1. General view of the direct Cosmological Simulations of the Growth of Black Holes and Galaxies [1,2]

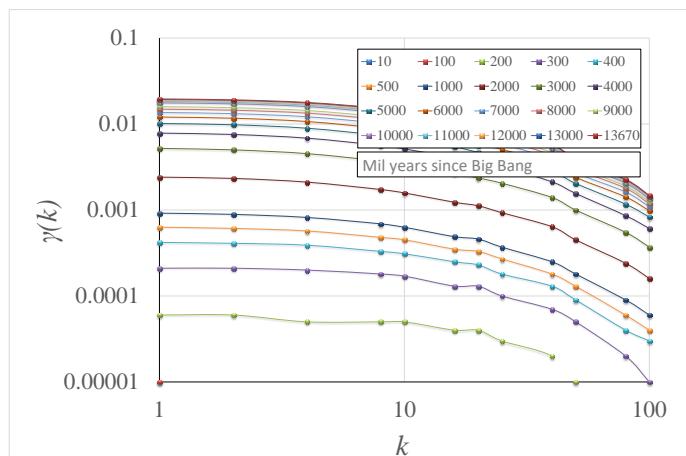


Figure S2. Climacograms of the Direct Cosmological Simulations of the Growth of Black Holes and Galaxies (Figure S1)

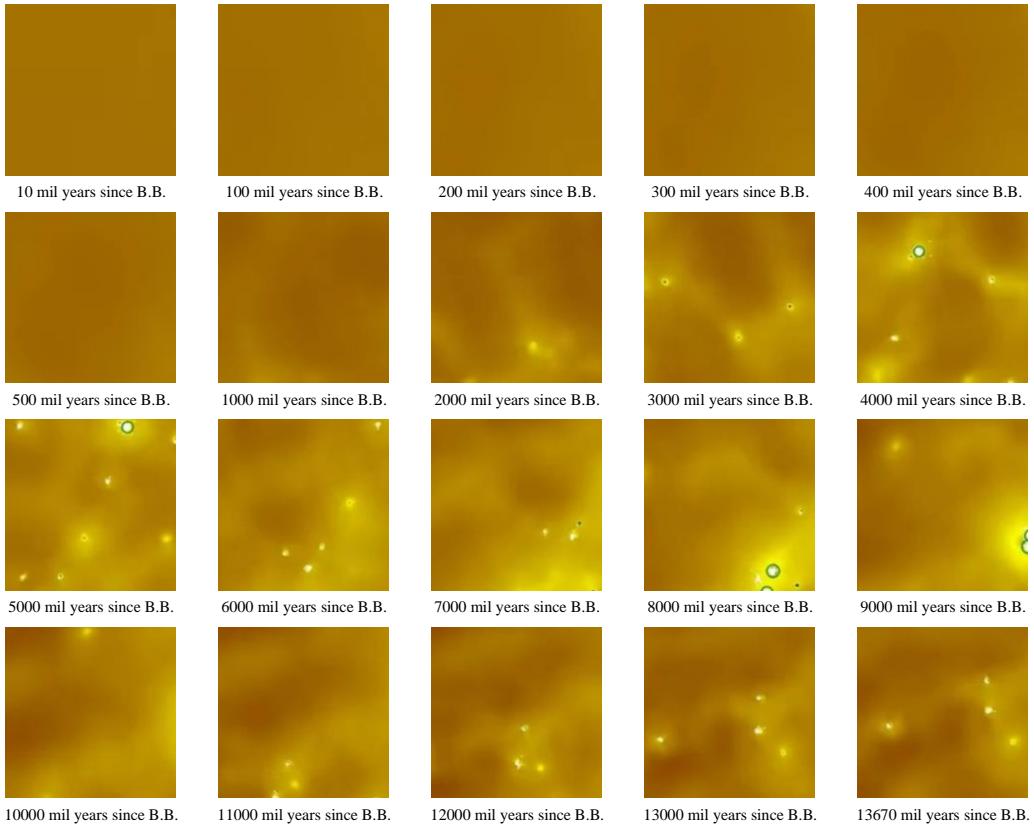


Figure S3. Closer zoom in an area of the direct Cosmological Simulations of the Growth of Black Holes and Galaxies [1]

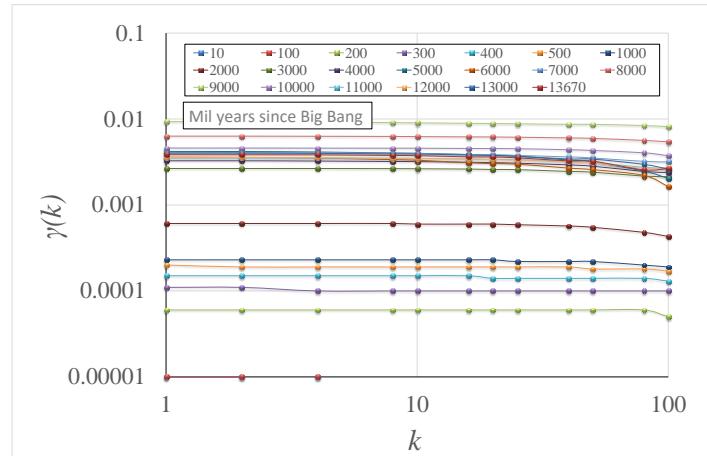


Figure S4. Climacograms of the closer zoom of Direct Cosmological Simulations of the Growth of Black Holes and Galaxies (Figure S2)

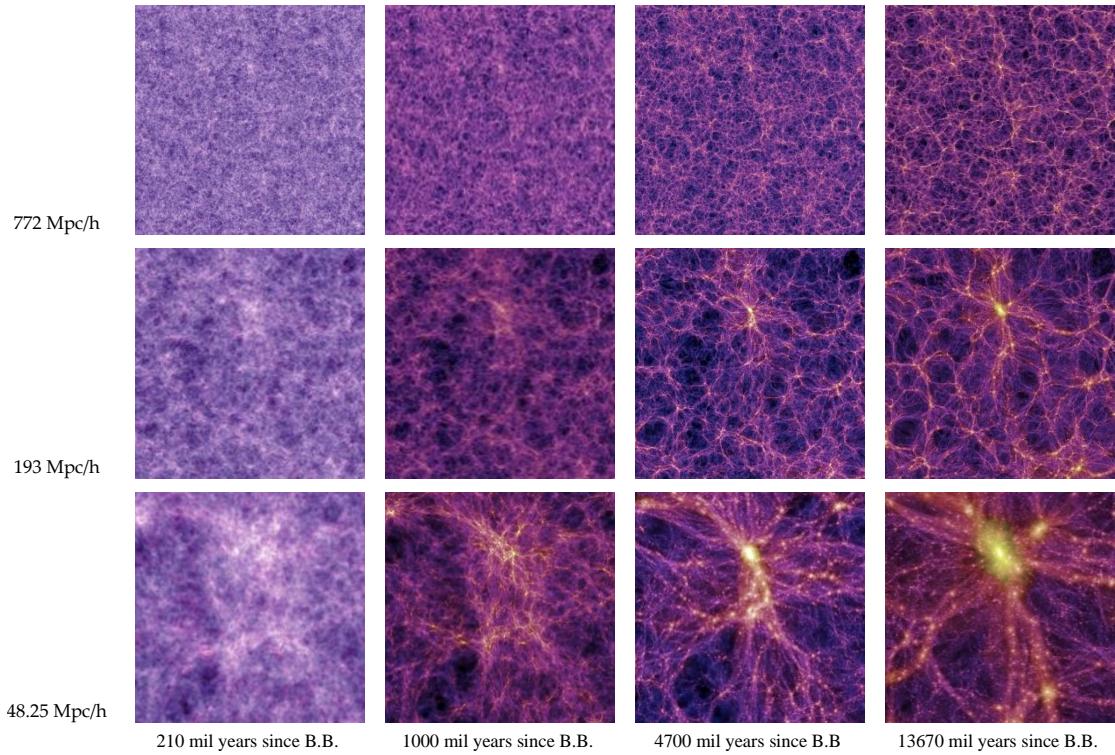


Figure S5. Evolution of the universe. Millennium Simulation Project [3]

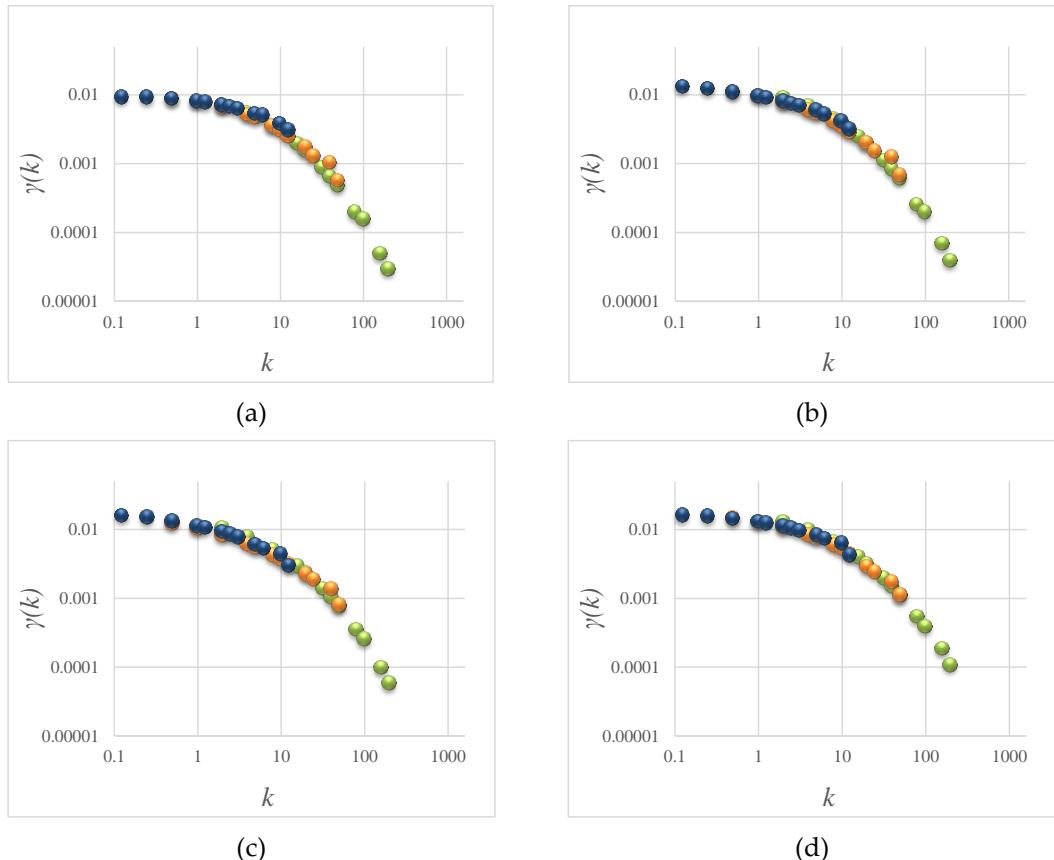


Figure S6. Fitting curves of composed climacograms of Millennium Simulation Project [3] (a) image series of 210 mil years after B.B.; (b) image series of 1000 mil years after B.B.; (c) image series of 4700 mil years after B.B.; (d) image series of 13600 mil years after B.B.

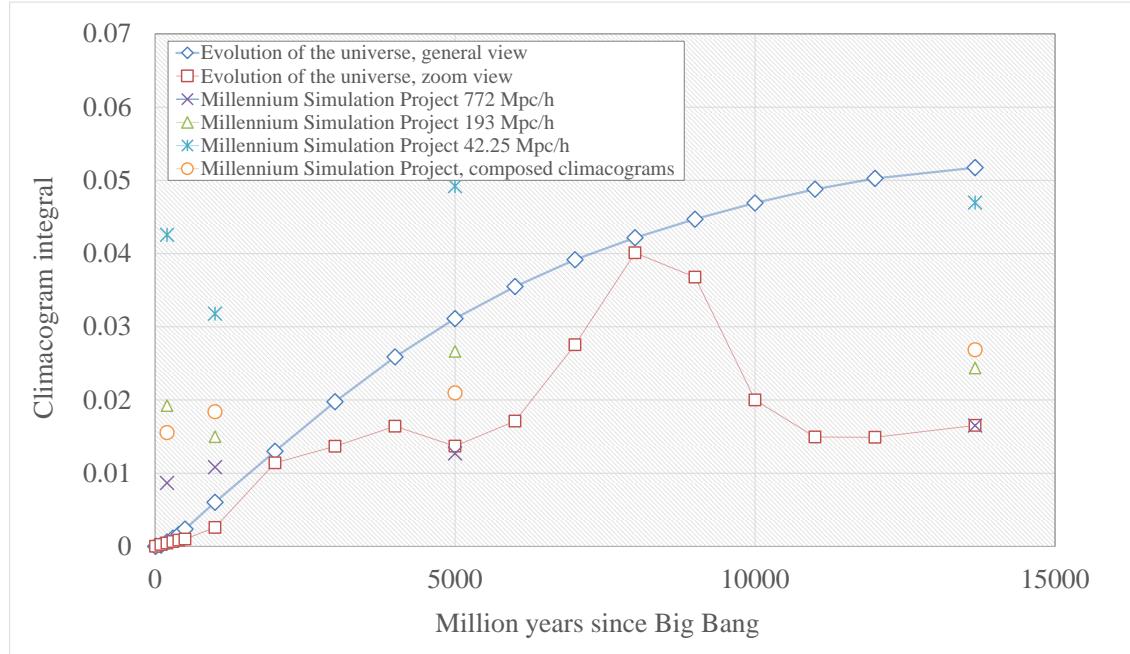


Figure S7. Rate of alteration of clustering through time of image series in Figures S1, S3, S5

2. Ecosystems

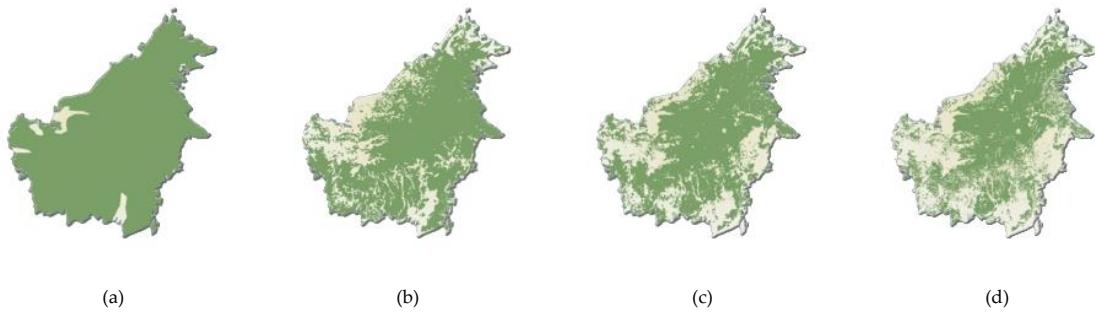


Figure S8. Deforestation in Borneo 1950-2005 (a) 1950; (b) 1985; (c) 2000 (d) 2005 [4]

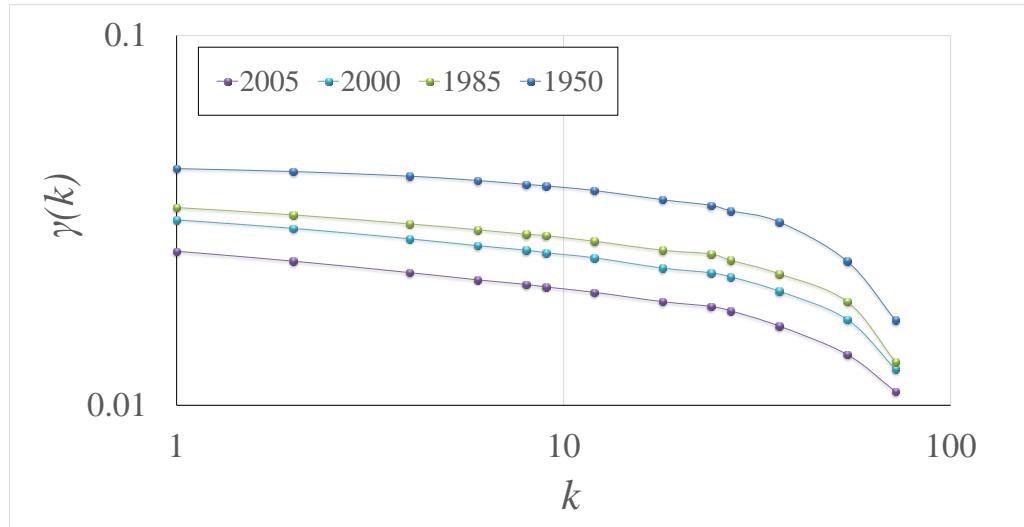


Figure S9. Climacograms of the deforestation in Borneo

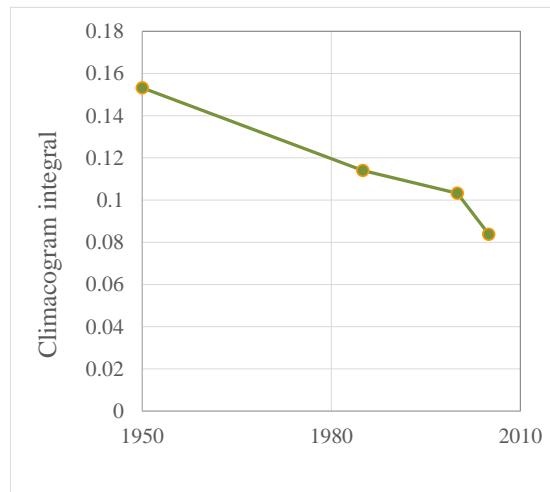


Figure S10. Evaluation of climacograms and rhythm of clustering in demolition of fosters' clustering in Borneo

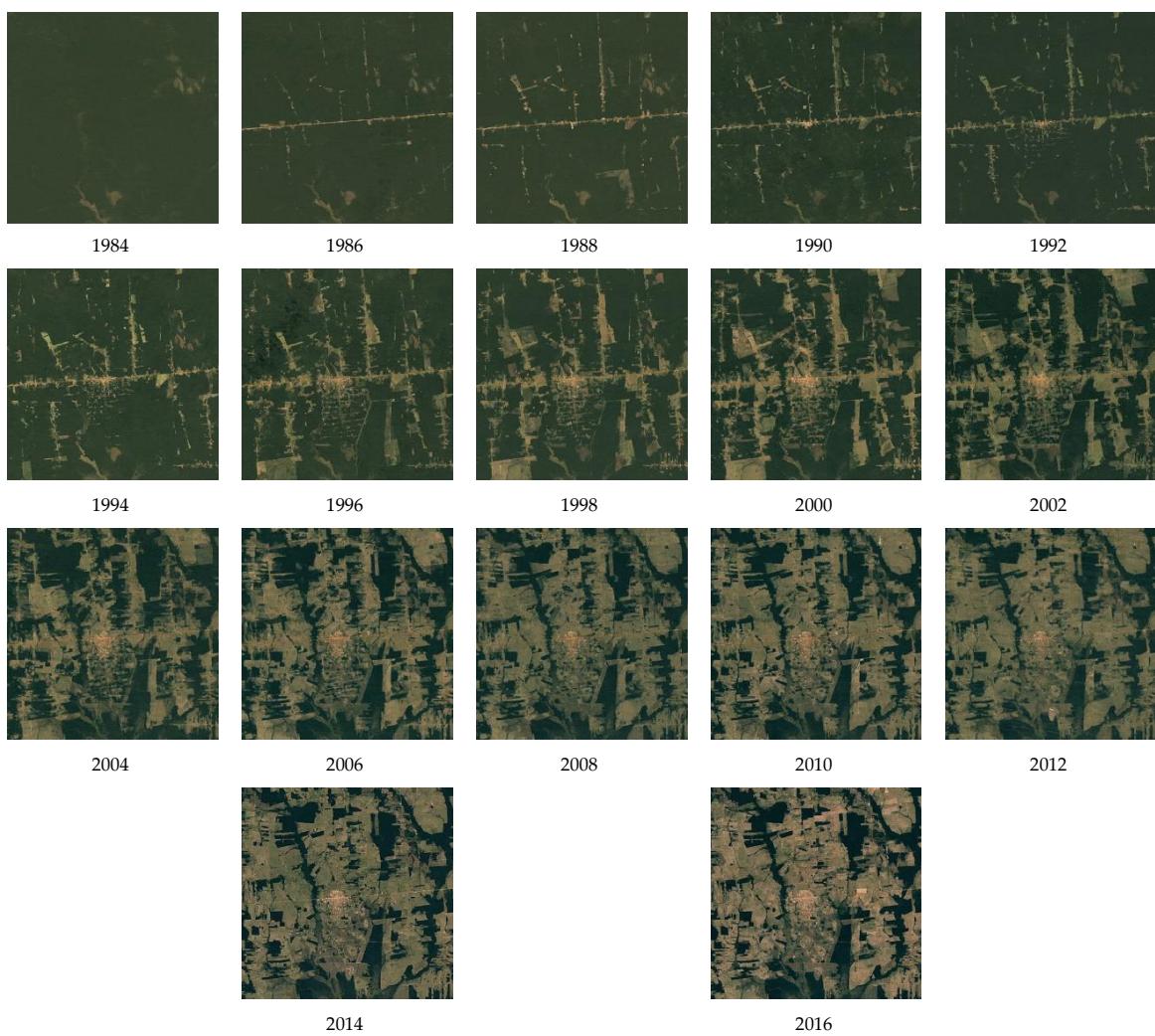


Figure S11. Deforestation of Amazon, creation of clustering of dry land and urban areas inside forest [5]

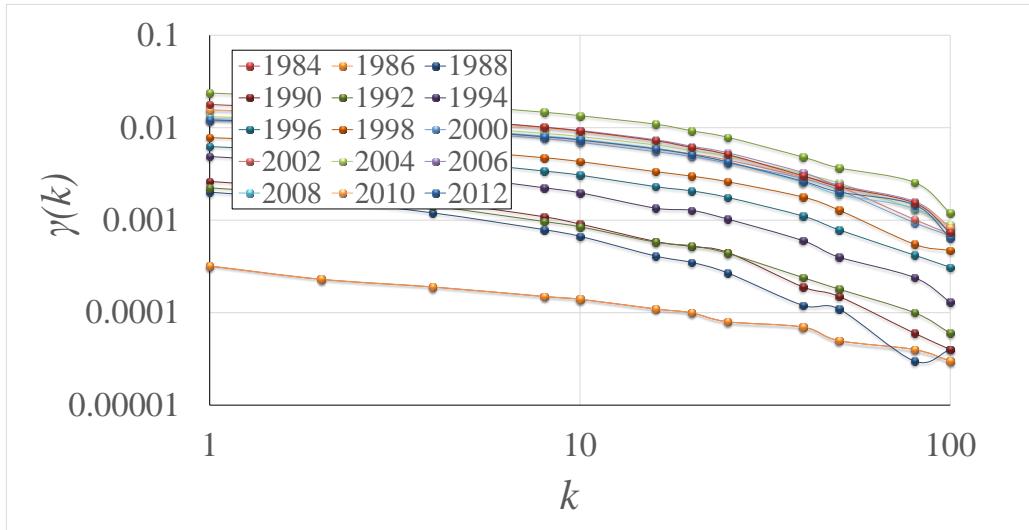


Figure S12. Climacograms of the deforestation in Amazon

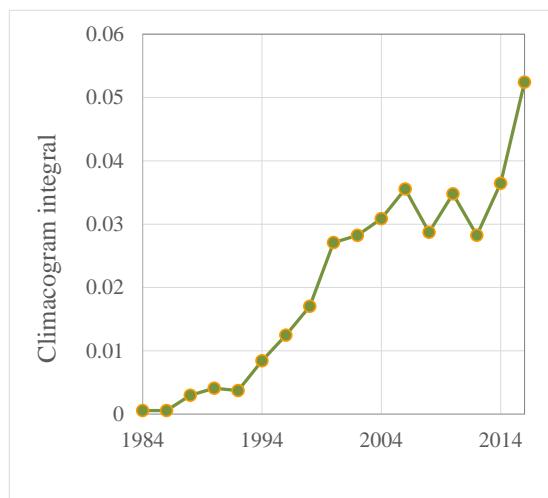


Figure S13. Evaluation of climacograms and rhythm of clustering evolution of dry-lands' clustering in Amazon

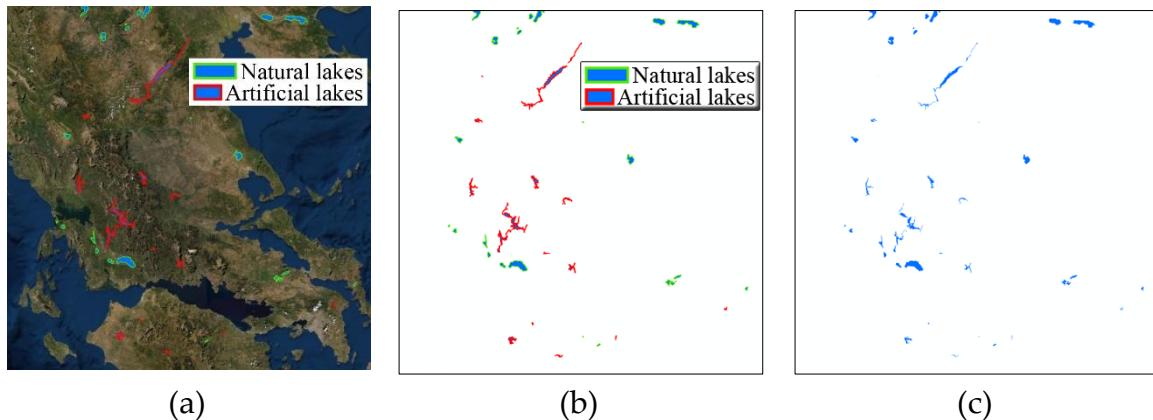


Figure S14. Greece, natural and artificial lakes (a) overview map of the area with natural and artificial lakes in 2020; (b) layer of the map; natural and artificial lakes 2020; (c) layer of the map; lakes 2020.

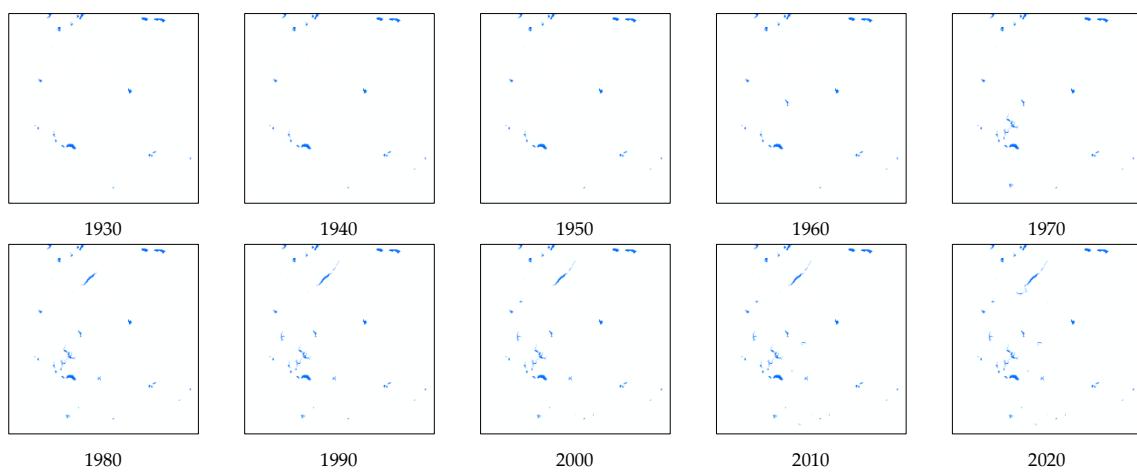


Figure S15. Evolution of water bodies in Greece as new big dams are constructed and new artificial lakes are created

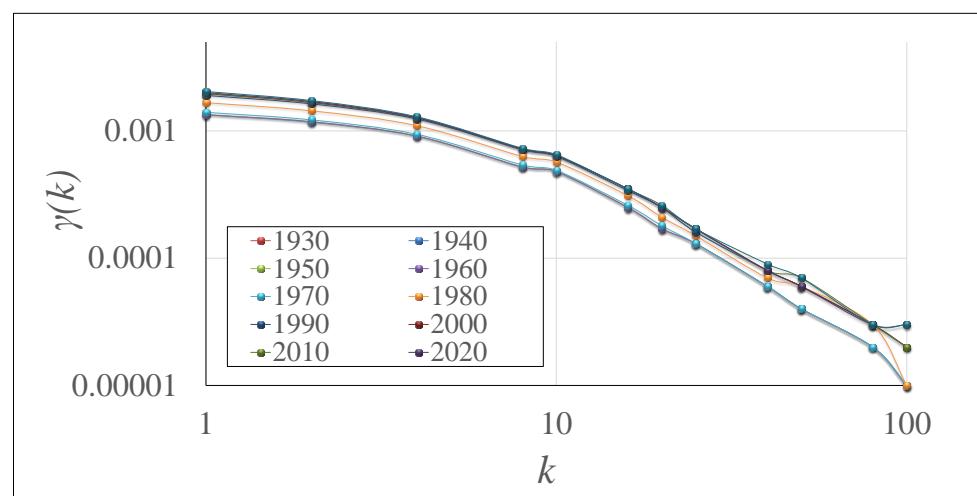


Figure S16. Climacograms of the evolution of water bodies in Greece

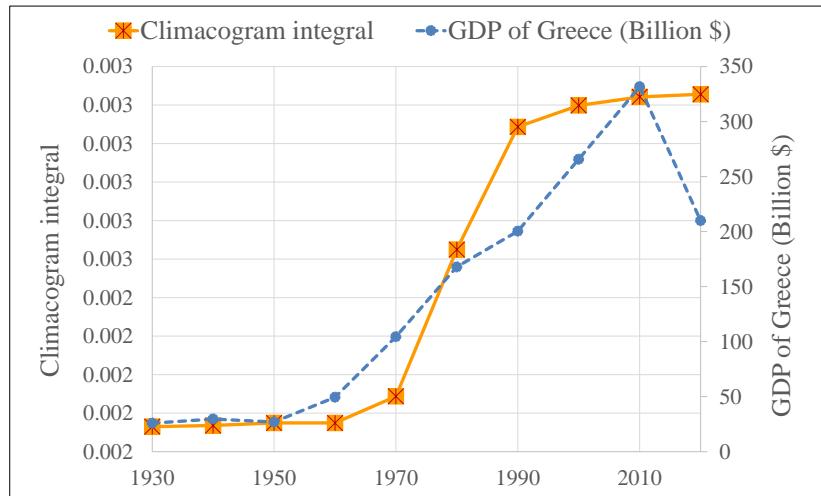


Figure S17. Rate of alteration of clustering through time of water bodies in Greece through the construction of large dams, related to GDP of Greece

3. Human society clustering

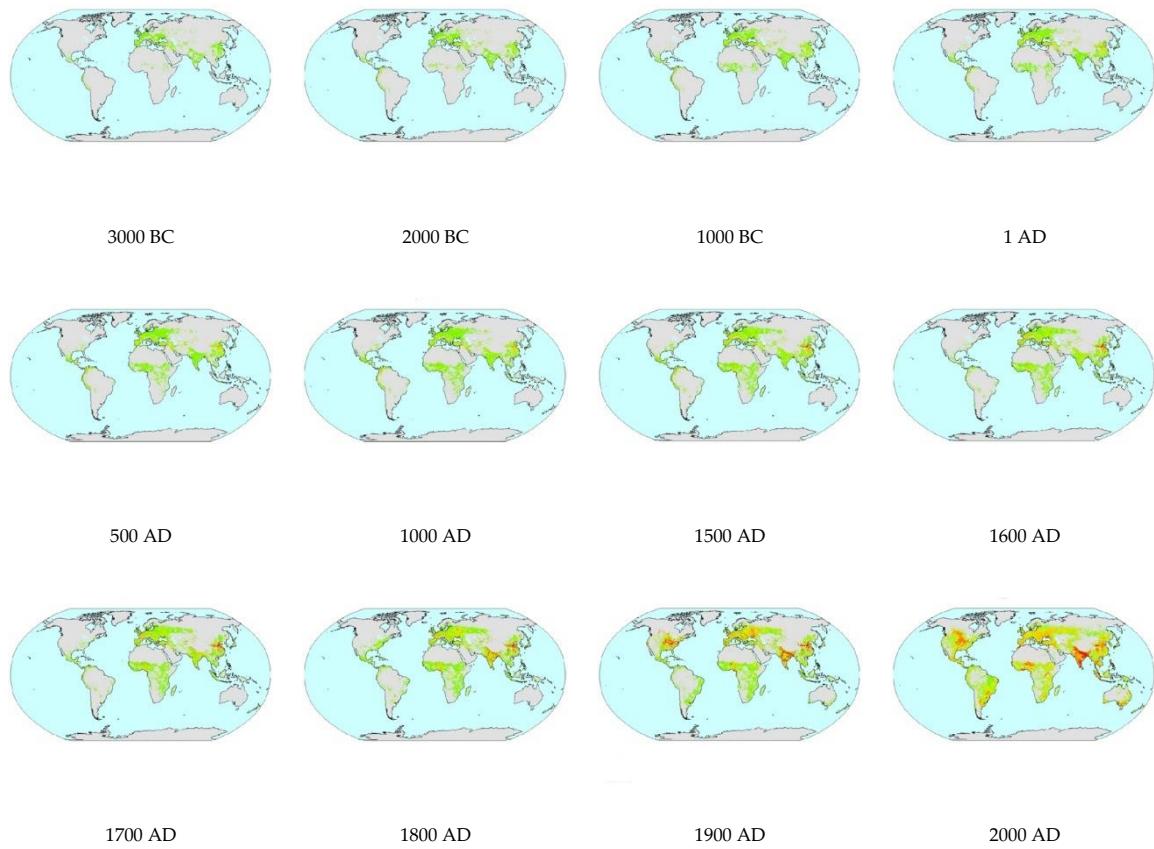


Figure S18. Evolution of cropland area; historical data from 3000 BC to AD 2000. [6]

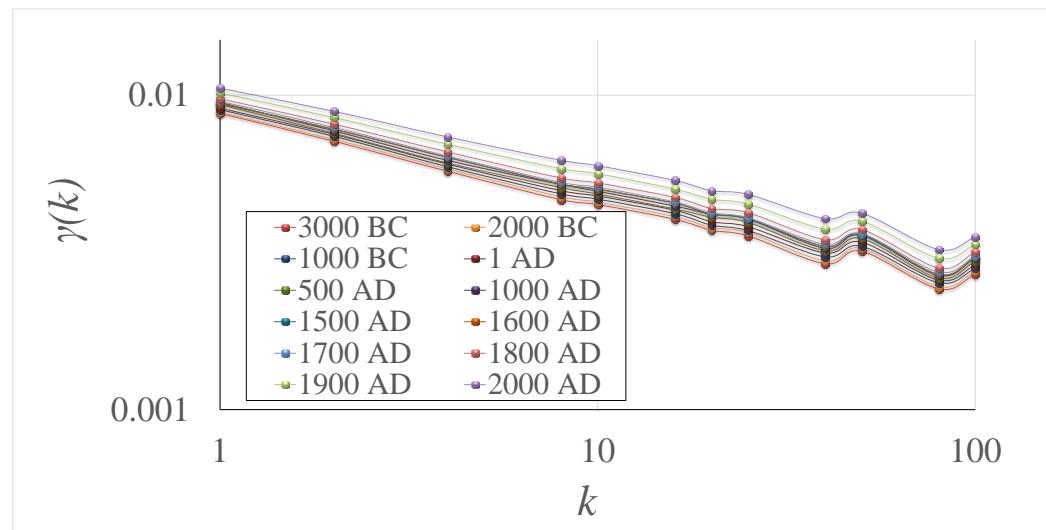


Figure S19. Climacograms of cropland areas

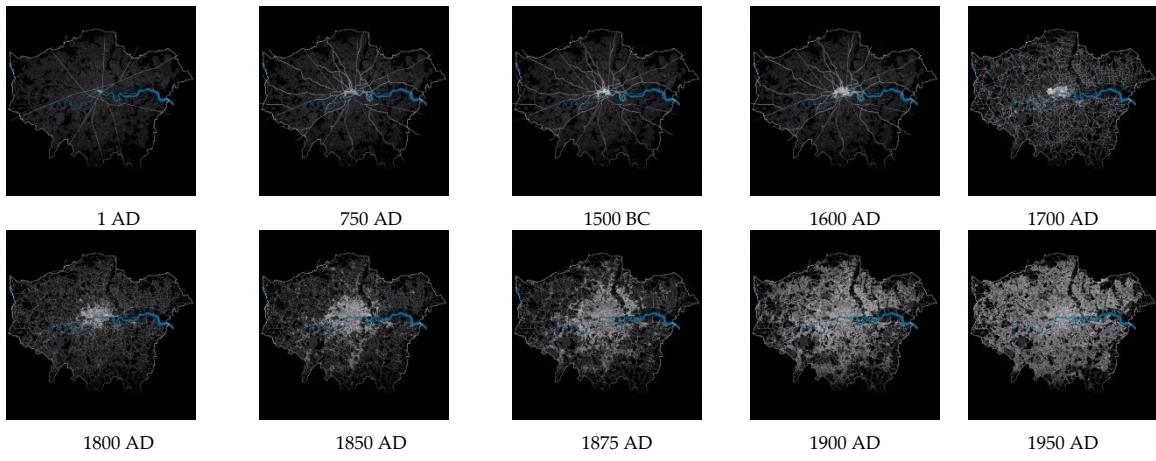


Figure S20. Evolution of London; historical data from 1 AD to 1950 AD. [7]

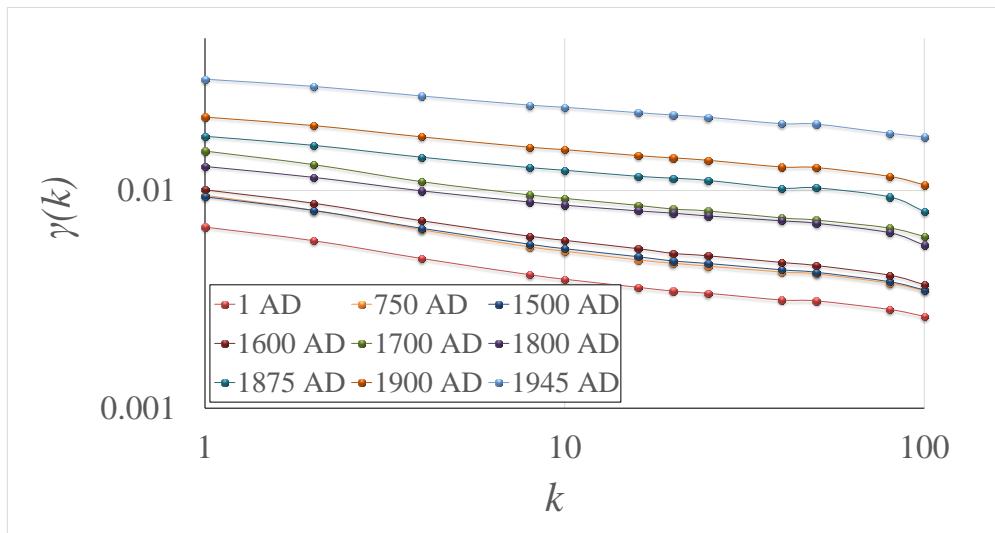


Figure S21. Climacograms. Clustering of urbanization of London

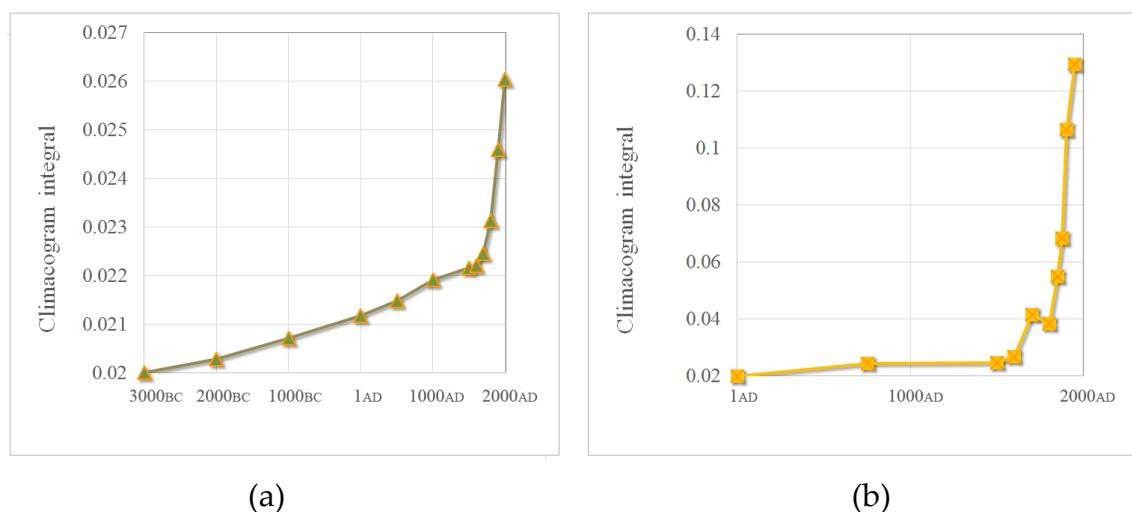


Figure S22. Evaluation of climacograms and rhythm of clustering (a) cropland land historical data (b) evolution of urbanization in London area

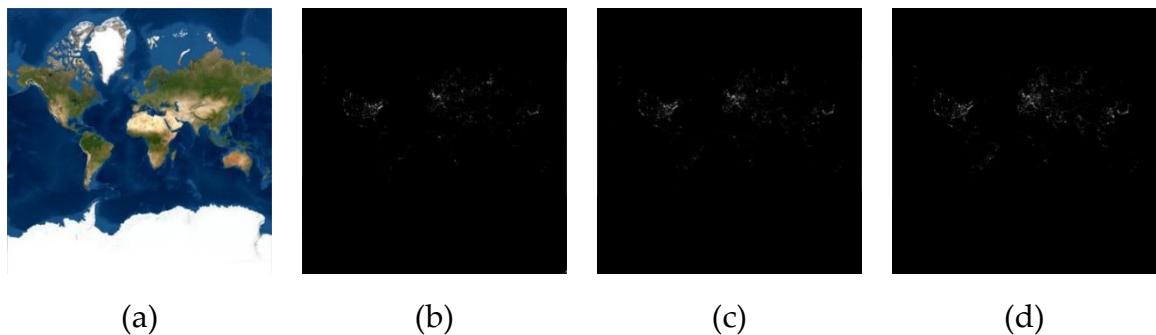


Figure S23. (a) Mercator projection of earth and its night lights in (b) 1992; (c) 2002; (d) 2012.

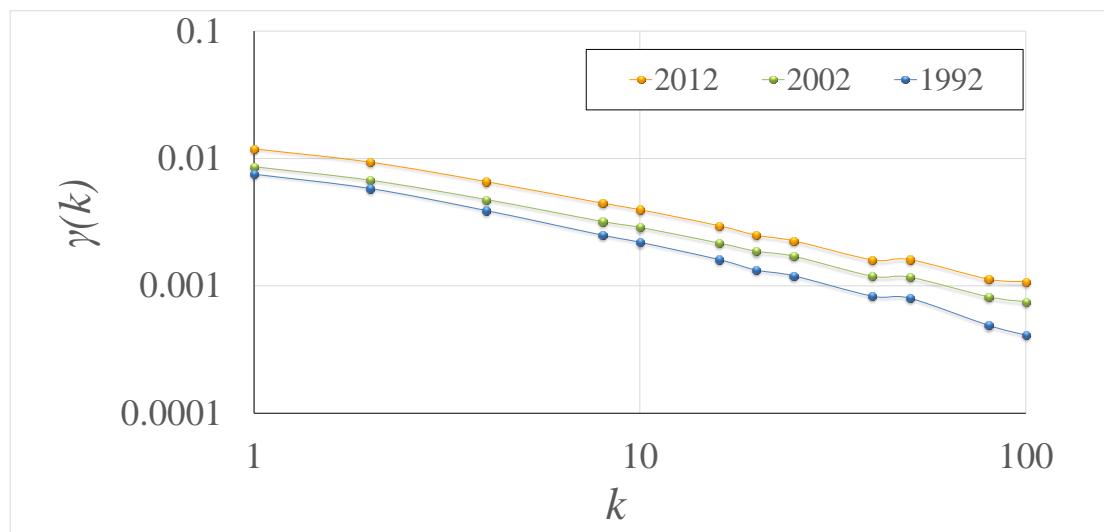


Figure S24. Climacograms of the images of night lights of the earth

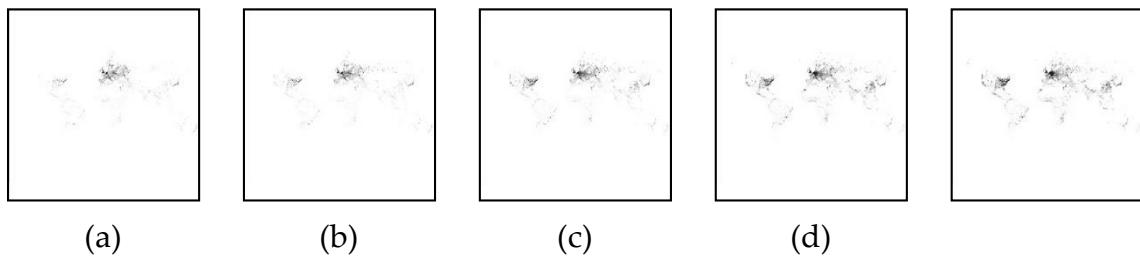


Figure S25. Earth in Mercator projection of urbanization in (a) 1900; (b) 1930; (c) 1960; (d) 1990; (e) 2010

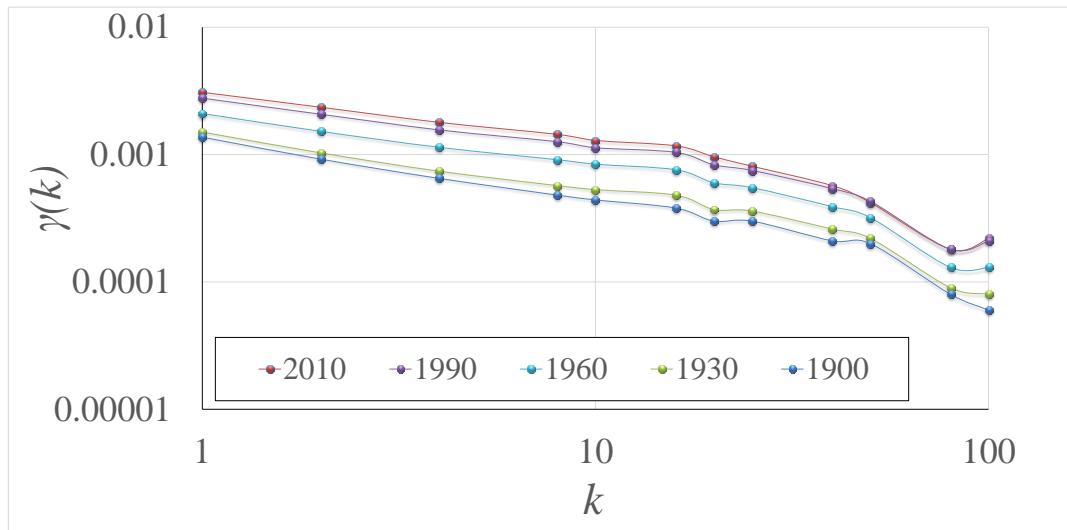


Figure S26. Climacograms of urbanization's clustering in worldwide

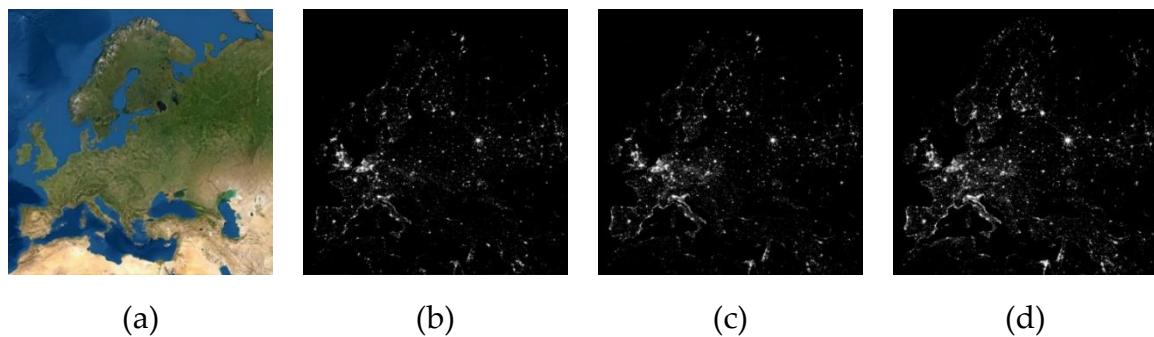


Figure S27. (a) Mercator projection of Europe and its night lights in (b) 1992; (c) 2002; (d) 2012.

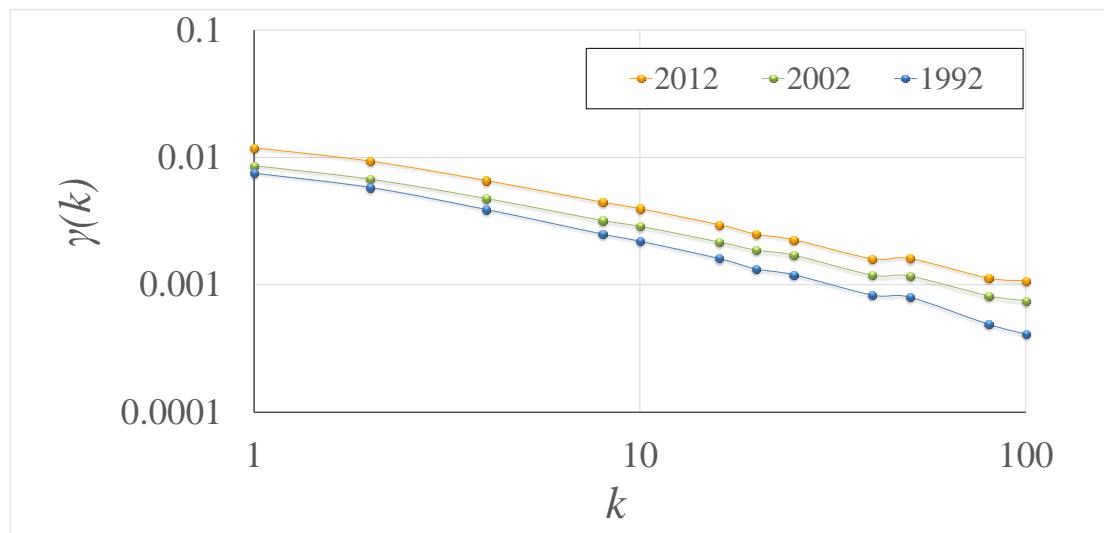


Figure S28. Climacograms of the images of city lights of Europe

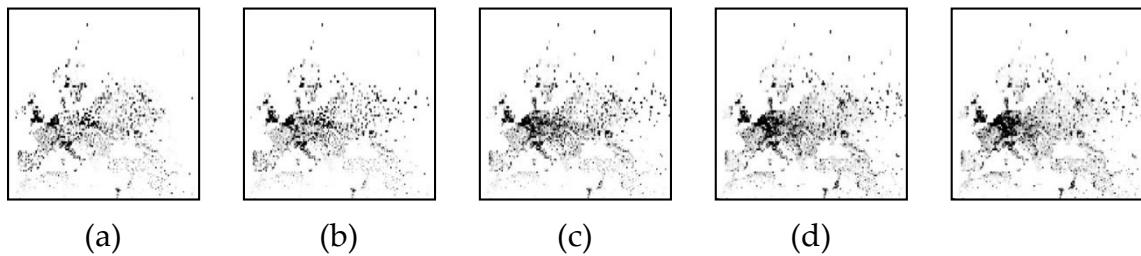


Figure S29. Europe in Mercator projection of urbanization in (a) 1900; (b) 1930; (c) 1960; (d) 1990; (e) 2010

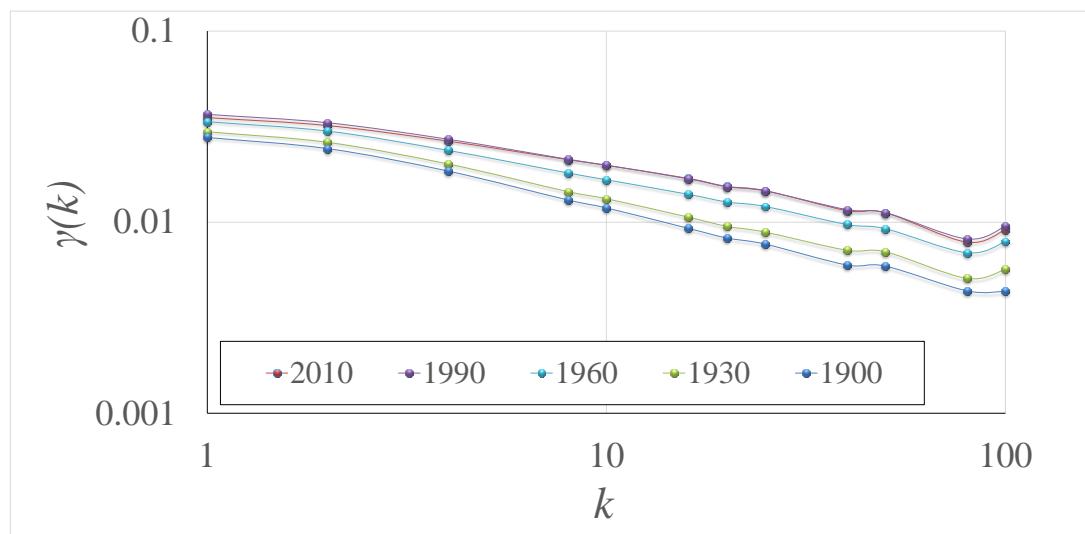


Figure S30. Climacograms of urbanization's clustering in Europe

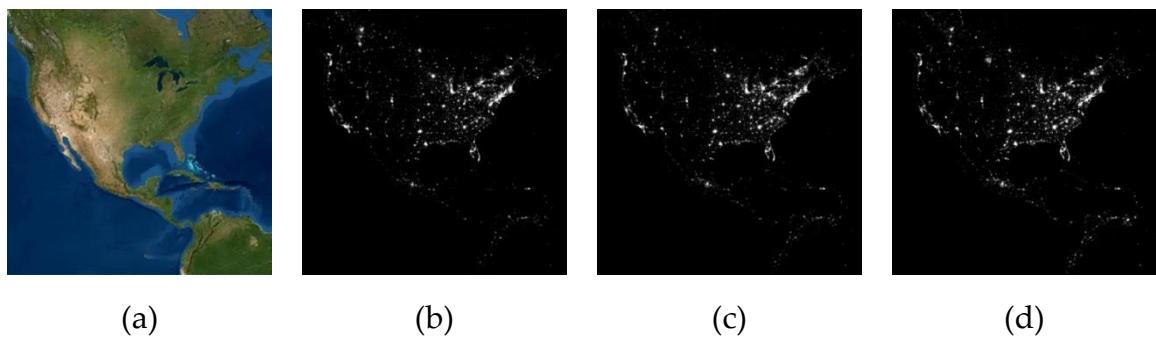


Figure S31. (a) Mercator projection of North America and its night lights in (b) 1992; (c) 2002; (d) 2012.

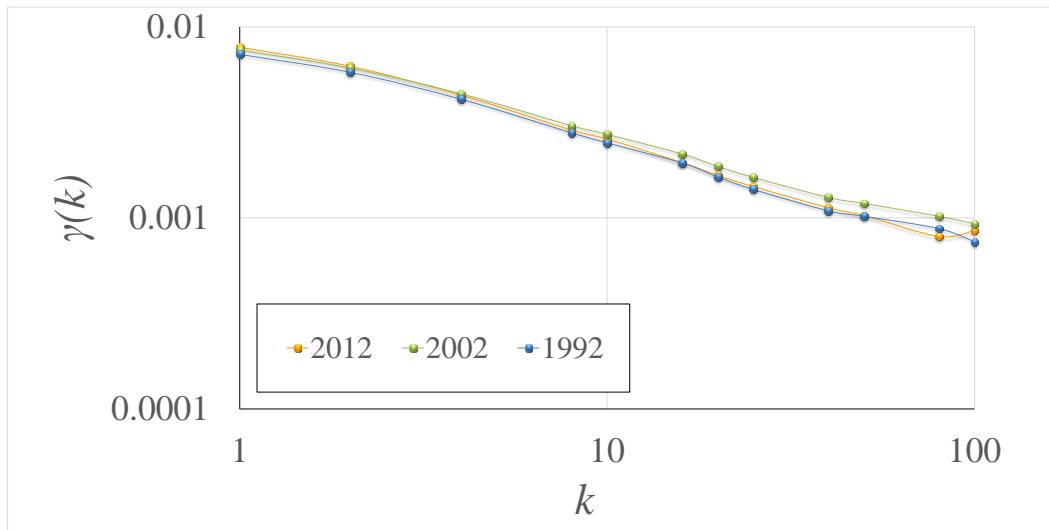


Figure S32. Climacograms of the images of city lights of Europe

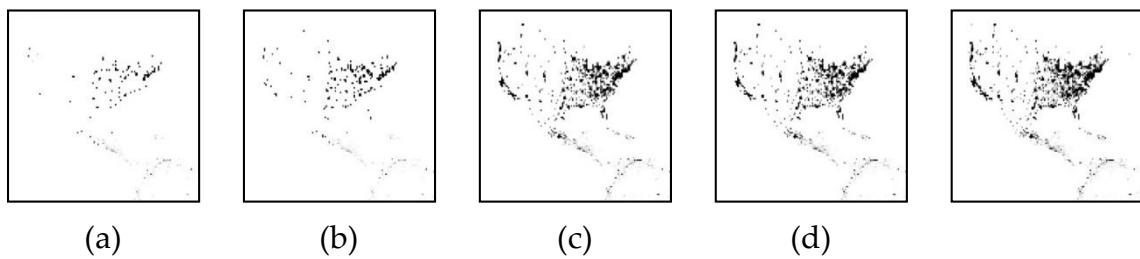


Figure S33. North America in Mercator projection of urbanization in (a) 1900; (b) 1930; (c) 1960; (d) 1990; (e) 2010

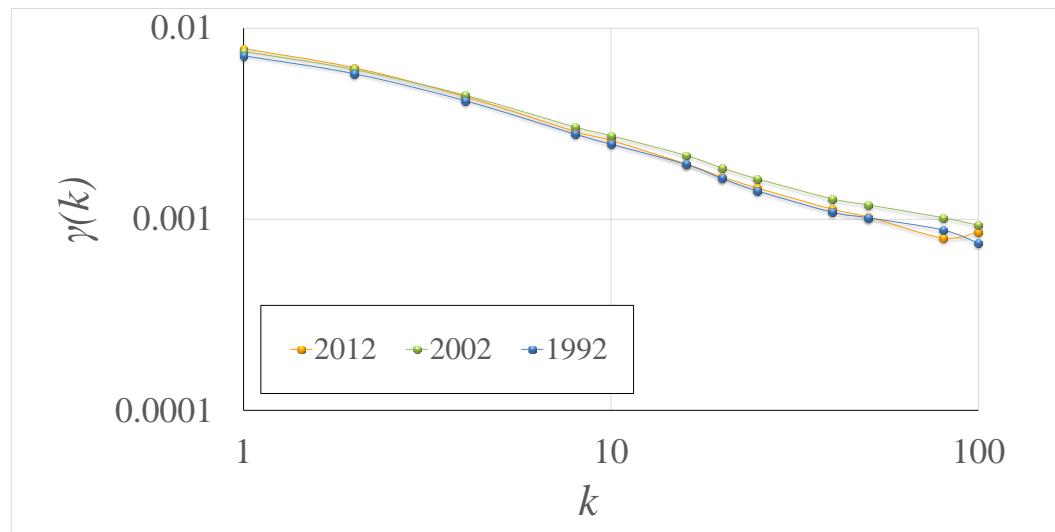


Figure S34. Climacograms of urbanization's clustering in America

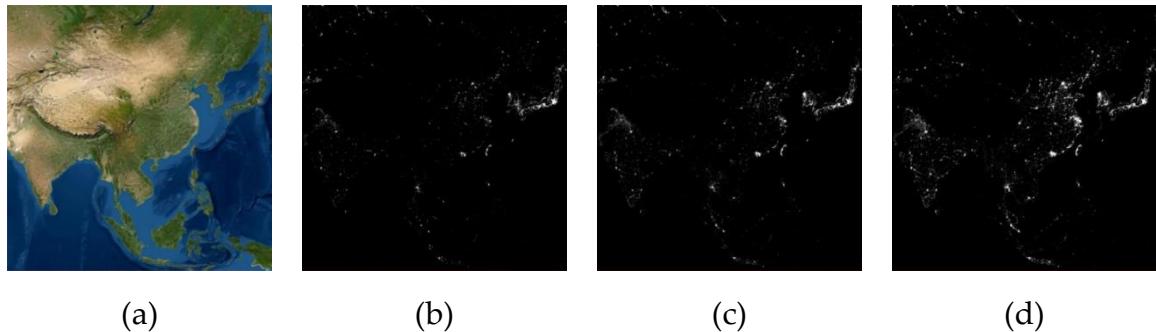


Figure S35. (a) Mercator projection of Asia and its night lights in (b) 1992; (c) 2002; (d) 2012.

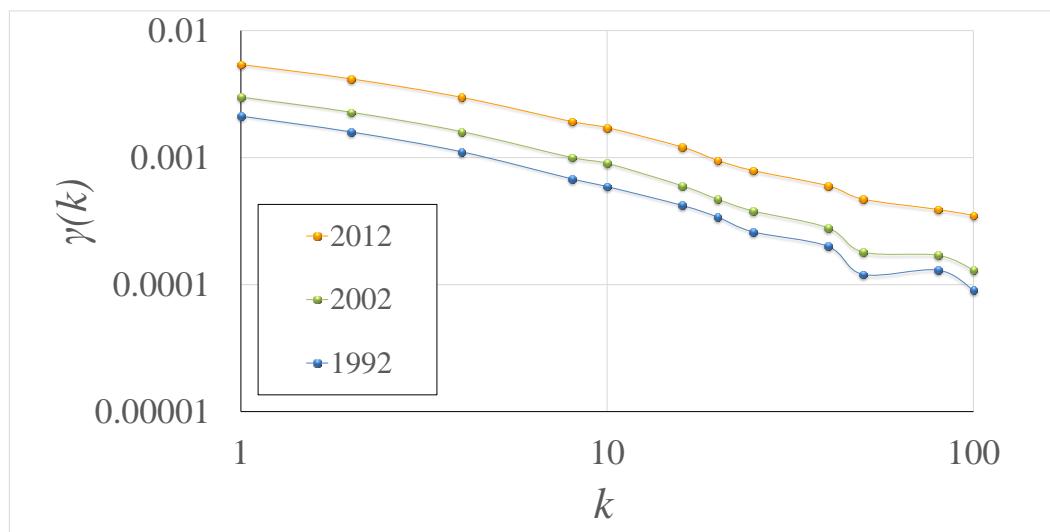


Figure S36. Climacograms of the images of city lights of Asia

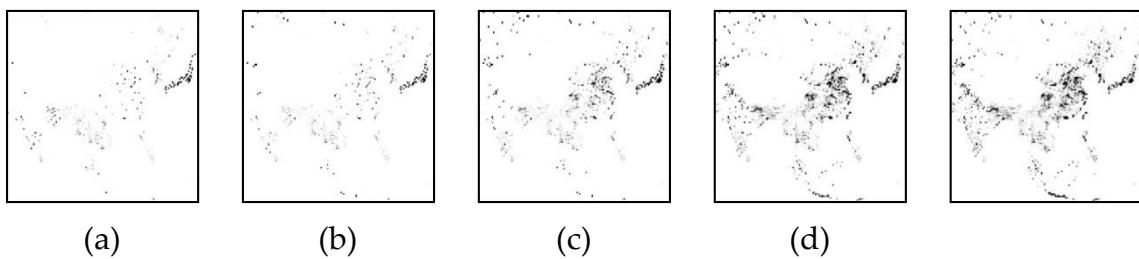


Figure S37. Asia in Mercator projection of urbanization in (a) 1900; (b) 1930; (c) 1960; (d) 1990; (e) 2010

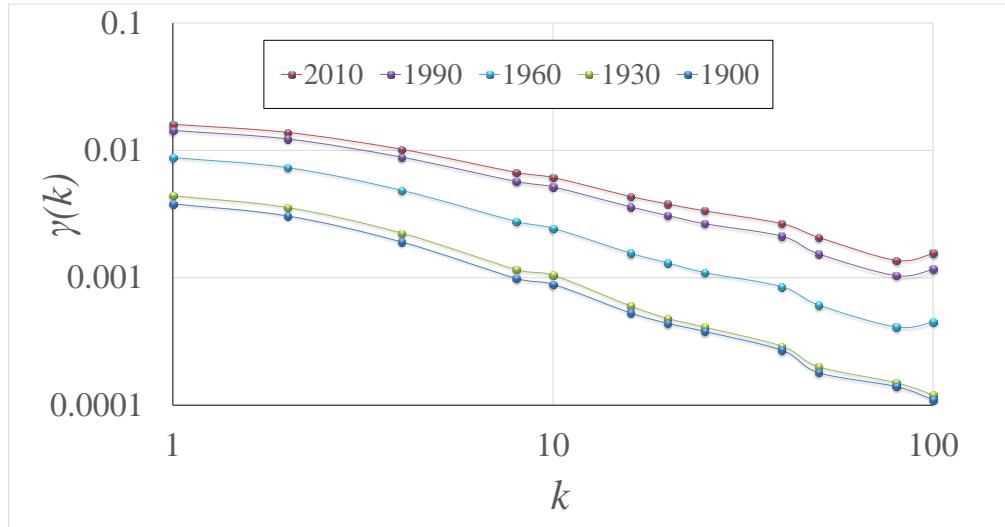


Figure S38. Climacograms of urbanization's clustering in Asia

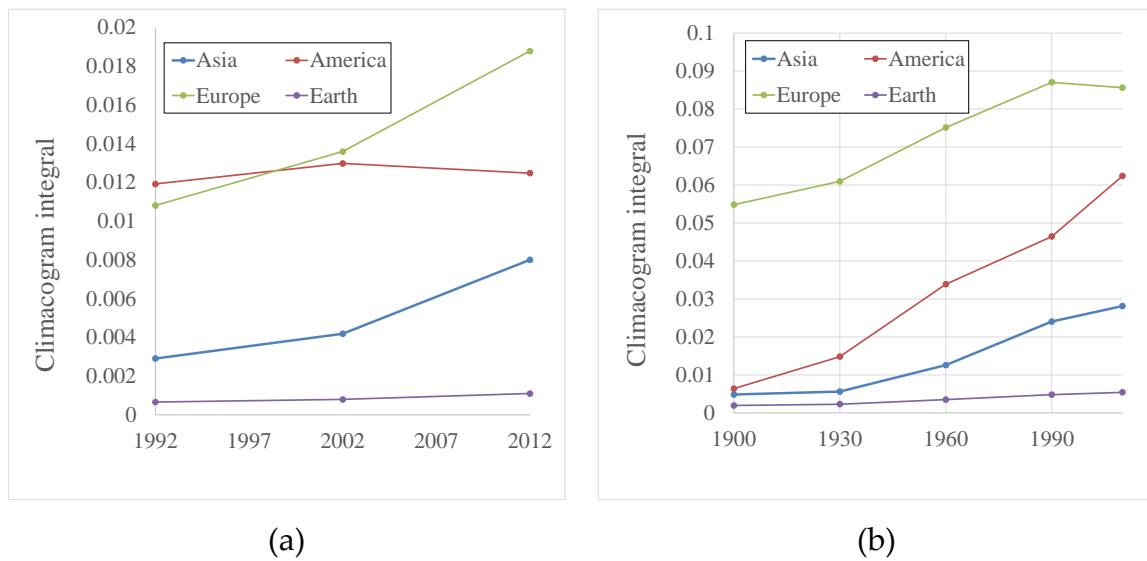


Figure S39. Evaluation of climacograms and rhythm of clustering (a) city lights (b) urbanization

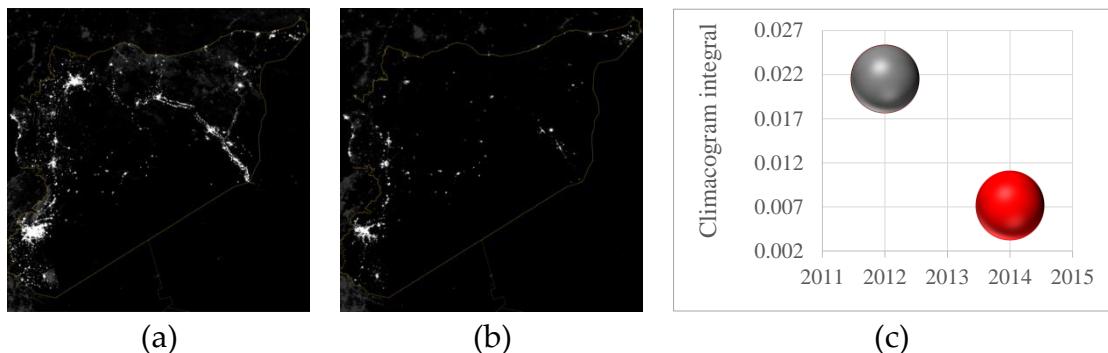


Figure. 40. Satellite night lights of Syria [8] (a) 2012; (b) 2014; (c) Rate of alteration of clustering before and after war

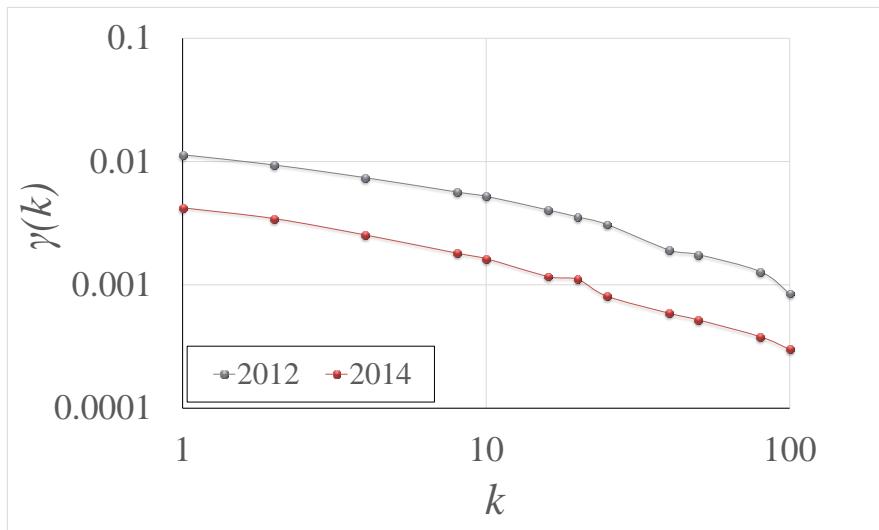


Figure S41. Climacograms, declustering of urbanization in Syria

References

1. Evolution of the universe Available online: http://timemachine.cmucreatelab.org/wiki/Early_Universe (accessed 24 August 2020).
2. Di Matteo, T., et al., 2008. Direct cosmological simulations of the growth of black holes and galaxies. *The Astrophysical Journal*, 676 (1), 33–53. doi:10.1086/524921
3. The Millennium Simulation Project Available online: <https://wwwmpa.mpa-garching.mpg.de/galform/virgo/millennium/> (accessed 16 September 2020).
4. Creator credit Hugo Ahlenius. Available online: <https://www.grida.no/resources/8324> (accessed on 15 September 2020).
5. The human impact on the world's forest, Available online: <https://www.visualcapitalist.com/human-impact-on-forests/> (accessed on 15 September 2020).
6. Klein Goldewijk, K.; Beusen, A.; van Drecht, G.; de Vos, M. The HYDE 3.1 spatially explicit database of human-induced global land-use change over the past 12,000 years. *Glob. Ecol. Biogeogr.* **2011**, *20*, 73–86, doi:10.1111/j.1466-8238.2010.00587.x.
7. The evolution of London: the city's near-2,000 year history mapped Available online: <https://www.theguardian.com/cities/2014/may/15/the-evolution-of-london-the-citys-near-2000-year-history-mapped> (accessed on 15 September 2020).
8. Syria After Four Years of Mayhem Available online: https://www.nytimes.com/interactive/2015/03/12/world/middleeast/syria-civil-war-after-four-years-map.html?mc_cid=bbe5eadb7&mc_eid=236cd449ae&_r=0 (accessed on 15 September 2020).