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Institut für
Theoretische Physik III

Network properties of meteorological stations in the river Elbe basin quantified by phase synchronization

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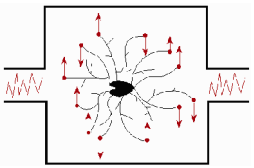
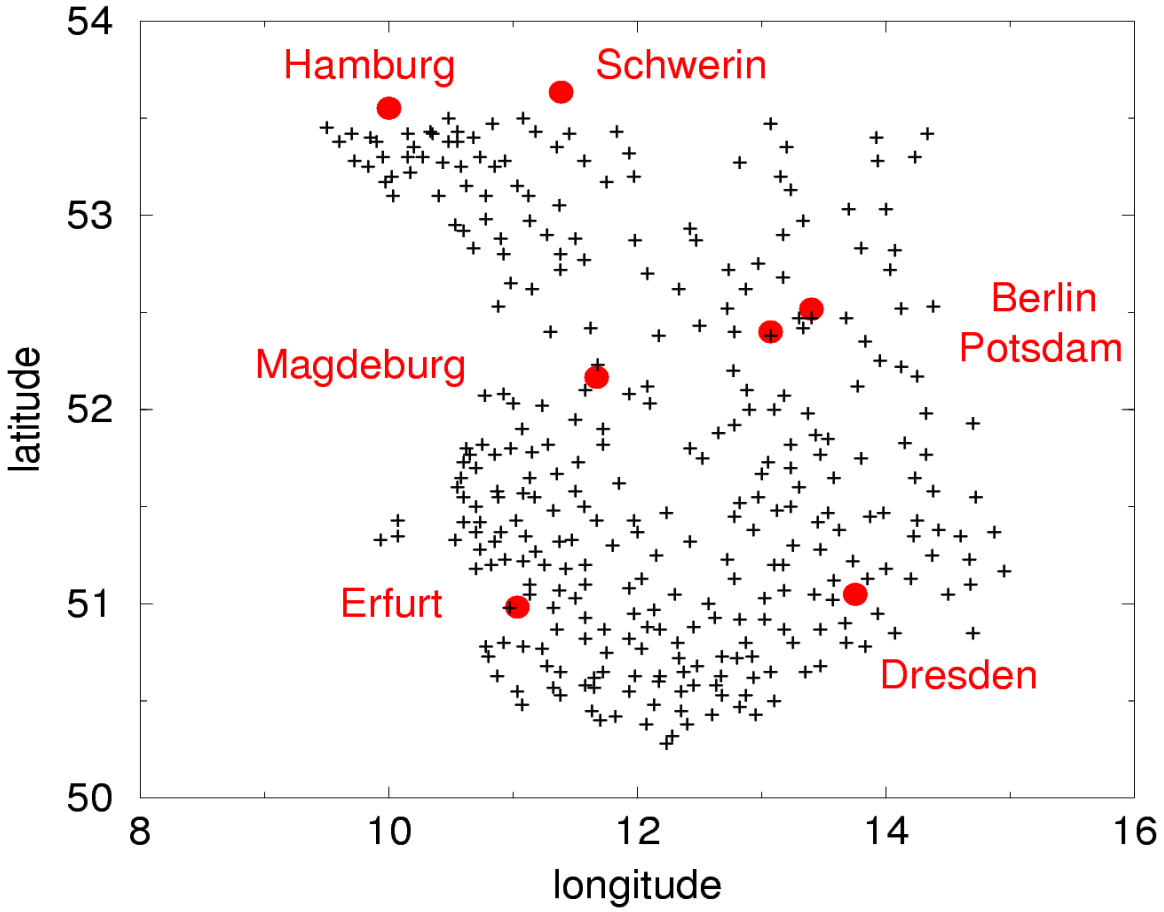
Mesoscopics, Fractals and Neural Networks



Data



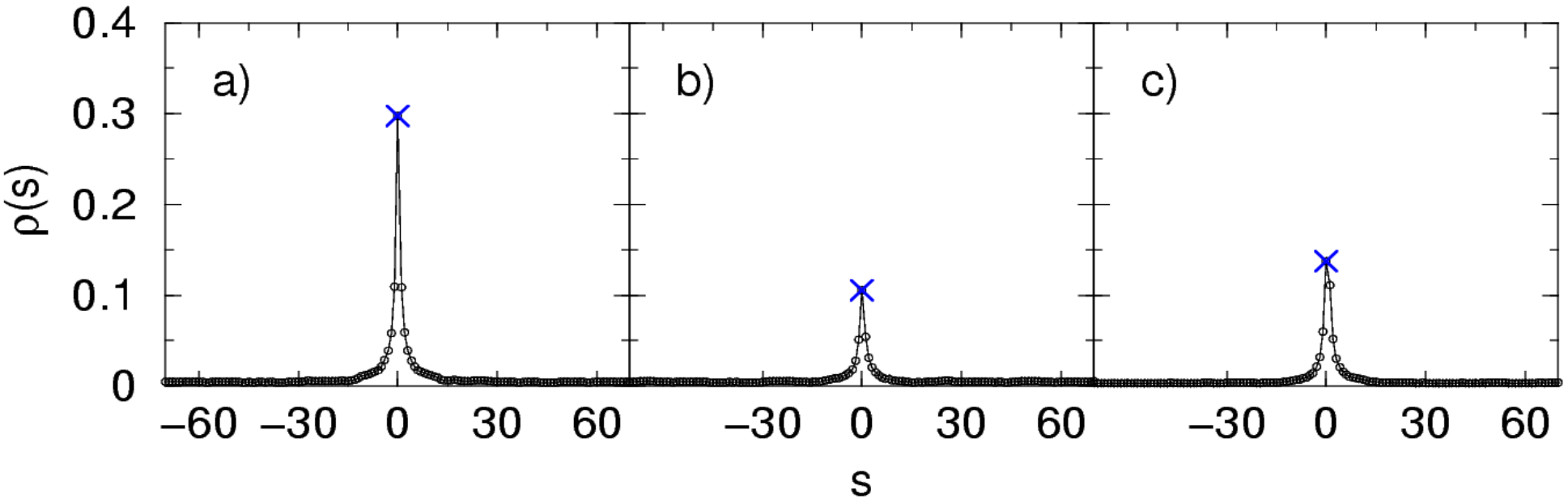
- 317 meteorological stations (nodes)
- daily precipitation (rainfall)
- length: 1951-2000 (18250)
- (317*316)/2 = 50086 combinations

Phase Synchronization Method

- quantification of synchronization in phases of two records
- statistical accumulation of certain phase differences
- synchronization index $0 < \rho(s) < 1$
  time lag (scale, shift) s
- similar results to cross-correlation
- but complementary information expected since only phases are used (amplitudes are neglected)
- References:

- P. Tass et al., Phys. Rev. Lett. **81** (1998) 3291.
- M.G. Rosenblum et al. in: "Neuro-Informatics and Neural Modelling, Handbook of Biological Physics" (Eds.: A.J. Hoff, F. Moss, S. Gielen), Vol. 4 (Chapter 9), Amsterdam, 2001.
- D. Rybski et al., Physica A **320** (2003) 601.
- L. Cimponeriu et al., Phys. Rev. E **70** (2004) 046213.

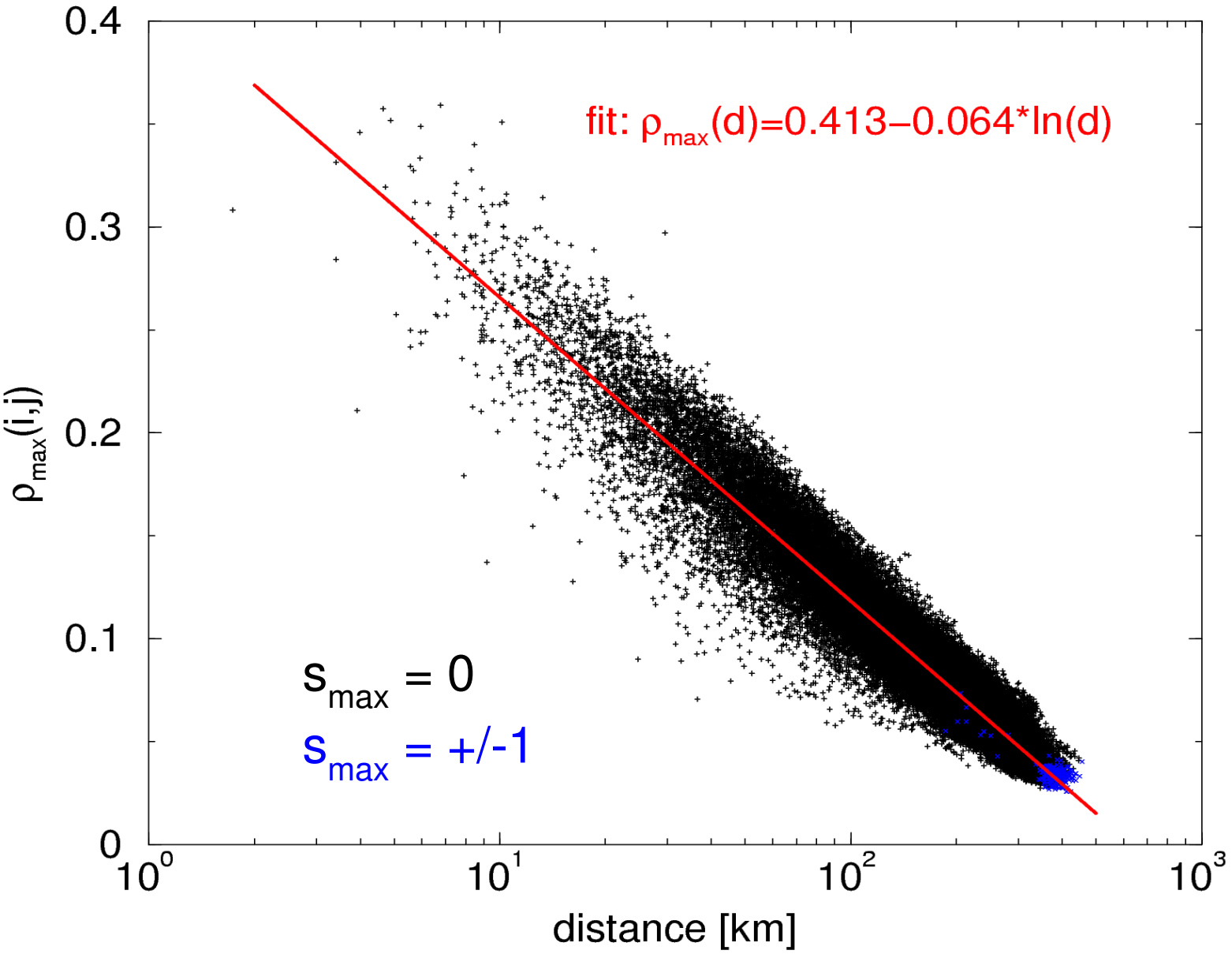
Results



a)	Loburg and Genthin	29.6 km	$\rho_{max} = 0.297$
b)	Oranienbaum and Güssefeld	124.4 km	$\rho_{max} = 0.105$
c)	Wernigerode (Hasserode) and Brocken	9.2 km	$\rho_{max} = 0.137$

- strength of optimum phase synchronization is strongly varying
- dependence on distance?

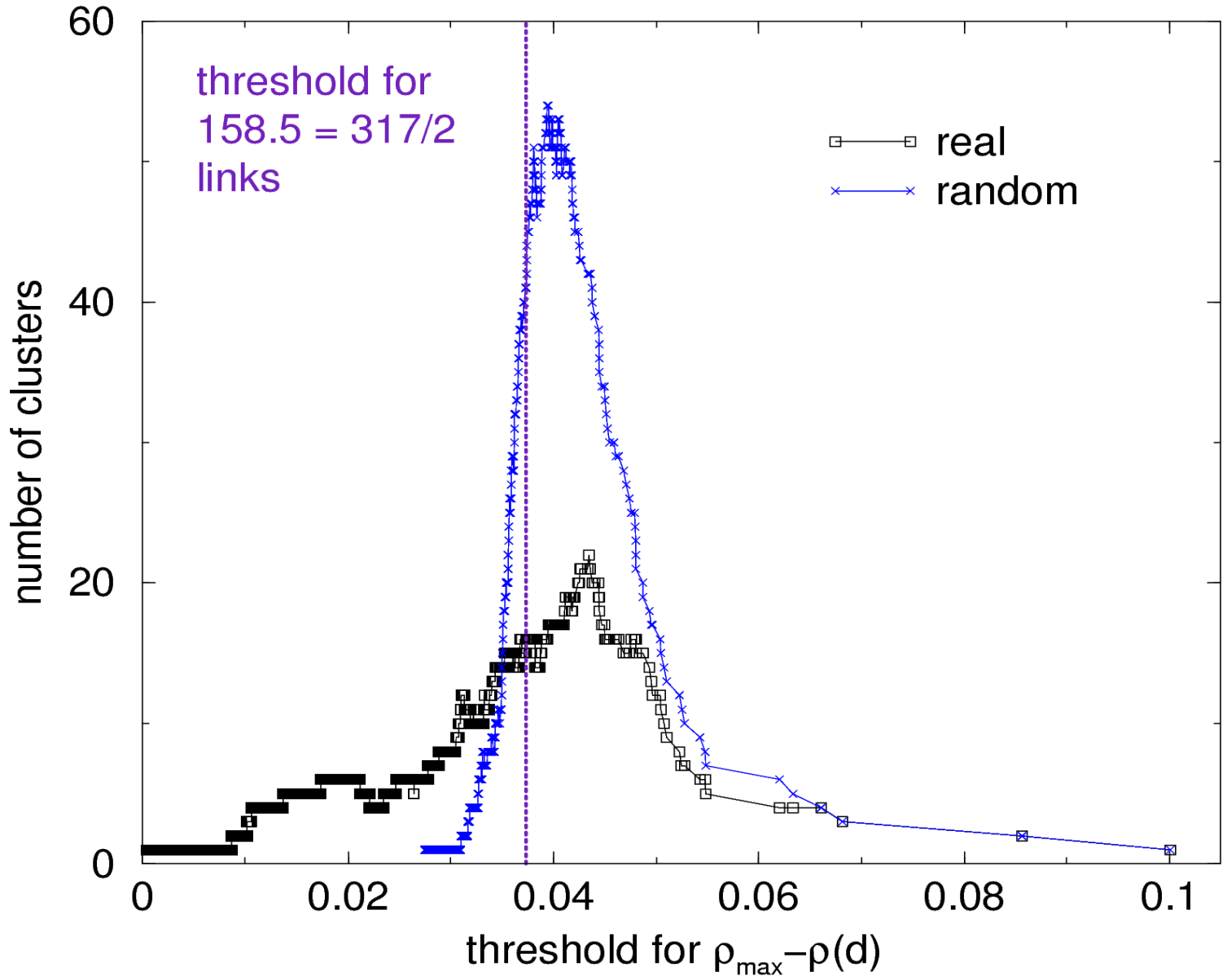
Dependence on distance



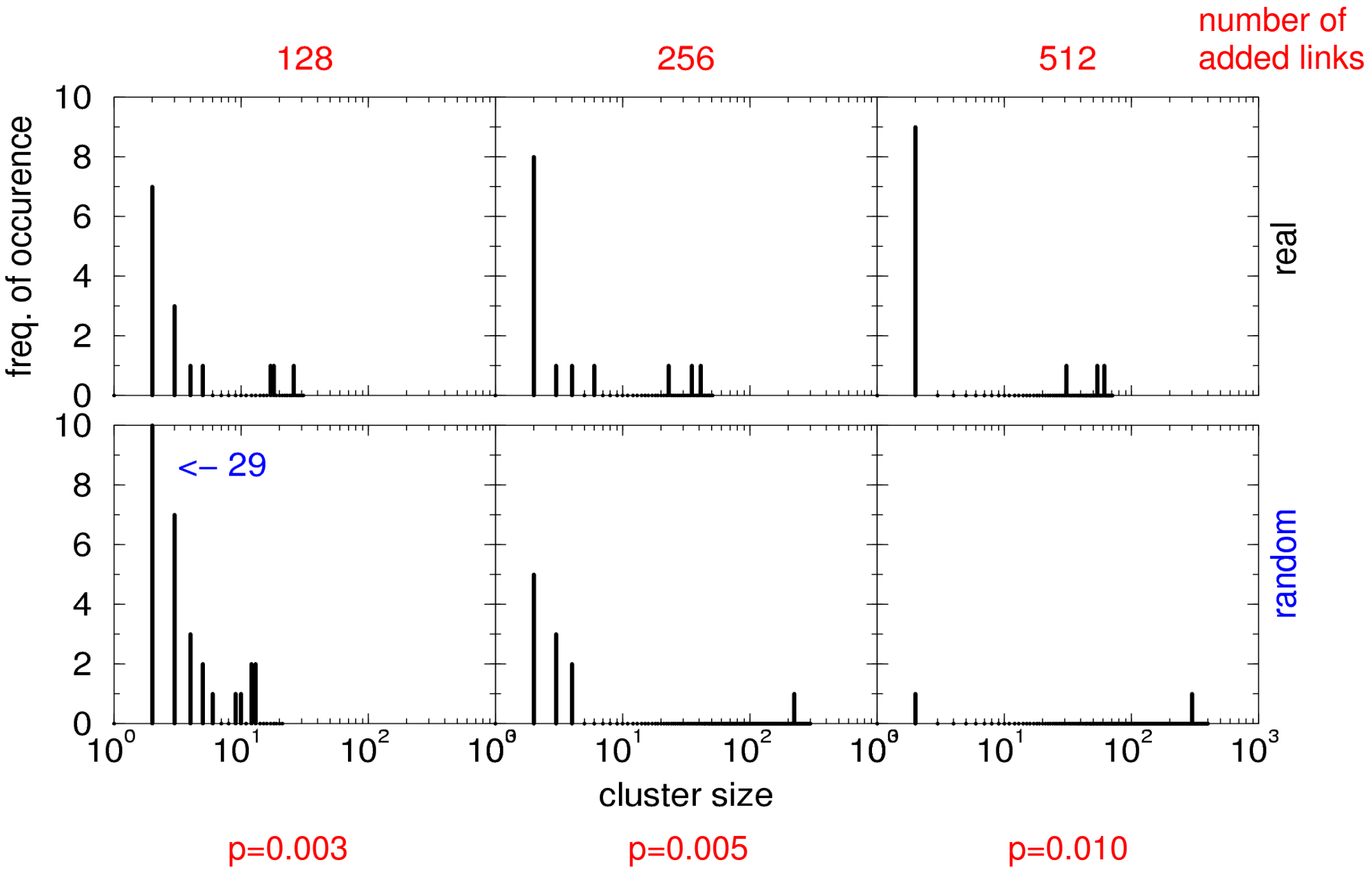
next:
connecting nodes with highest relative phase synchronization

- network
- clusters

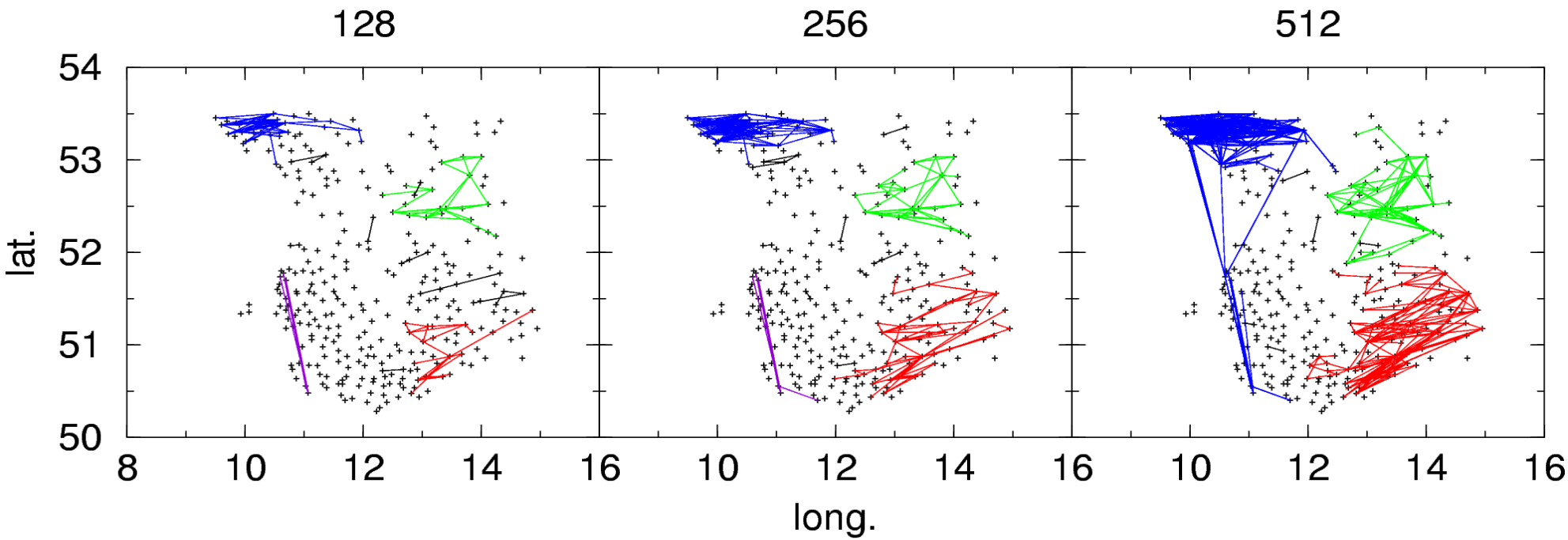
Number of clusters



Size of clusters



Climate Graphs

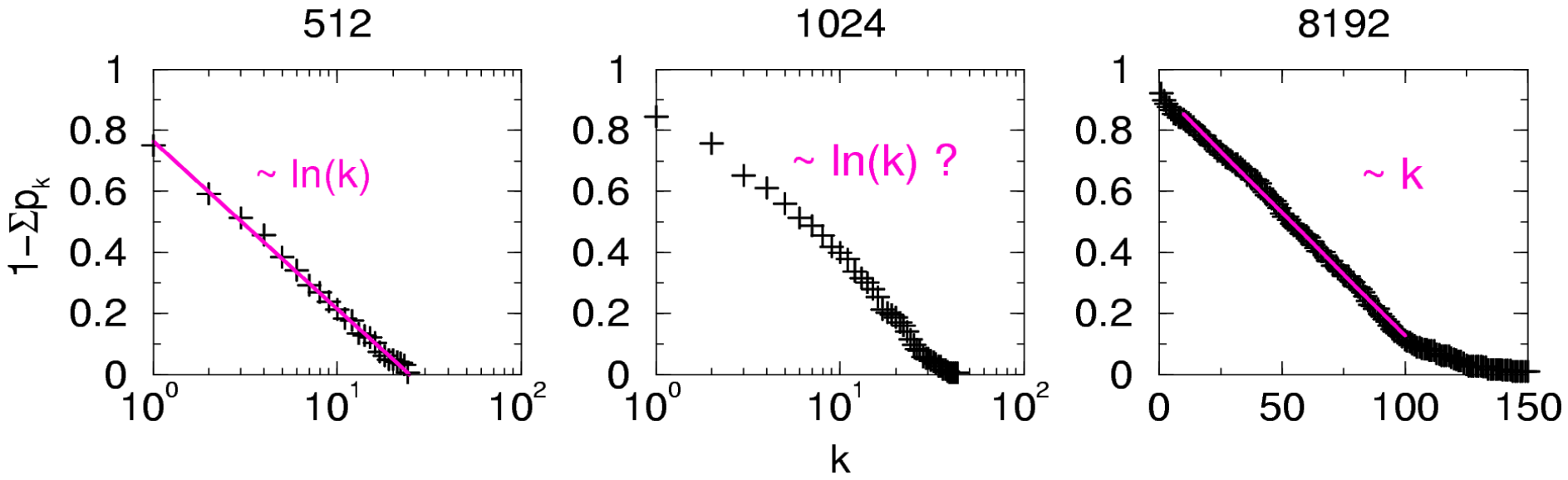


- densely connected big clusters
- clusters distinct in space
- few small clusters

522 -> 523: 2 clusters
566 -> 567: 1 cluster
p_c approx. 0.01

Degree Distribution

- number of nodes with certain amount of links (normalized)
- here: cumulative histogram



p=0.010 p=0.020 p=0.164

$p_k \sim 1/k$ ... ? ... = const. ...

Summary

- network-construction by strength of phase synchronization
- subtracting trivial dependence of distance
- highly connected big clusters
- critical concentration higher than for the random case
- clusters distinct in space
- changing degree distribution (evolving network)
- References:
  - A.A. Tsonis et al., Physica A **333** (2004) 497.
  - J.-P. Onnela et al., Eur. Phys. J. B **38** (2004) 353.

Acknowledgements

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